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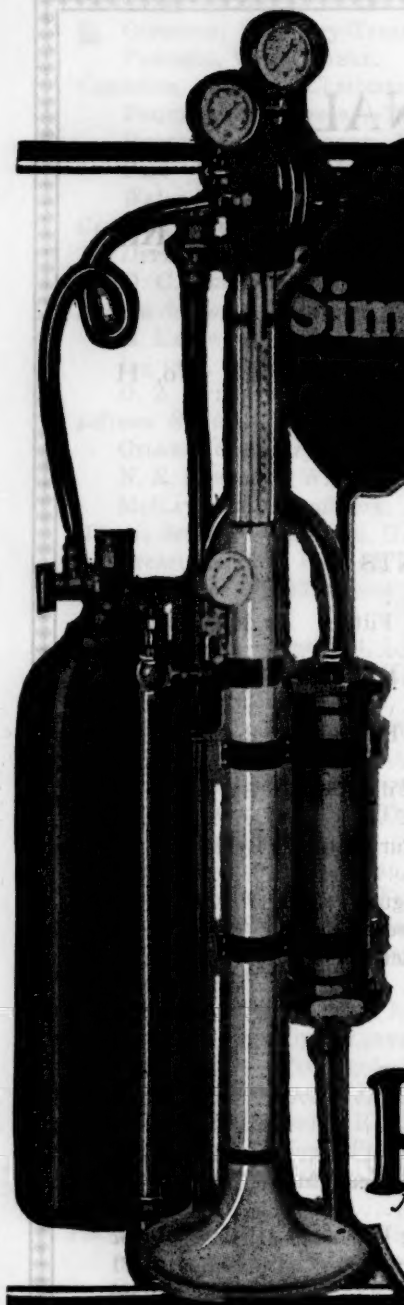
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STUDIES ON THE WASHING OF RAPID FILTERS¹

BY ROBERTS HULBERT² AND FRANK W. HERRING³

PART I. EXPERIENCE WITH CLEAN SAND, SAND CLEANING AND HIGH WASH RATES FOR RAPID FILTERS

Wolman and Powell's article, "The Surface Shrinkage of Rapid Filter Sand Beds" appearing in Engineering News-Record, July 1920 (Vol. 85, No. 5) started a general and interesting discussion of the possible causes for this common disease of rapid filters. A number of authorities contributed to the discussion, and not a few different hypotheses were proposed to account for the phenomenon. In substance, Wolman and Powell's conclusions were that the filter sands most subject to shrinkage were those with high absorptive quality, and that this absorptive capacity of sand depended more upon the surface or internal structure of the grains than upon the presence of a colloidal film. In the discussion there appeared to be, substantially, a lack of agreement with these conclusions, or, for that matter, upon any other single explanation. In studying the article and the controversy that followed it, one becomes a bit bewildered in the scientific byways that seem to cross each other. Which one of these is the straight and narrow path out of the woods?

A few quotations from the above mentioned controversy show

¹ Presented before the Central States Section meeting, September 17, 1929.

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that for a long time there has been a tendency to connect filter bed shrinkage with coating of the sand grains and mud formations in the bed. Ellms states (Eng. News-Record Vol. 85, No. 10, p. 439) that he "has never observed shrinkage cracks in new sand beds when first put in service" and concludes "that the shrinkage cracks were the result of the accumulation of a certain amount of organic and inorganic matter upon the sand." Allen Hazen says (Ibid., p. 440) that "a pure, clean, silica sand shows but little shrinkage . . . any impurities will tend to hold the grains slightly apart . . . and more shrinkage will follow when pressure is applied." Again, Weston states (Ibid., p. 439) that he believes that "shrinkage will not occur in filters having good wash water distribution." In Stein's text, "Water Purification Plants and Their Operation," under the heading of "Filter Washing" is found this statement: "the surface (of the sand bed) should be covered with a uniform film of jelly . . . removing this the sand should be absolutely clean. . . . The presence of mud uniformly distributed would indicate too short a period of washing or too low a rate."

The writers have recently gained experience in the operation of experimental rapid filters in which the sand was successfully kept clean. By that is meant that the sand grains themselves were almost entirely free from coating, and the bed perfectly free from any semblance of mud accumulation whatever, if the usual, thin, mud coat, or "schmutzdecke" on the sand surface be excepted. These results were accomplished by using a wash rate high enough to expand the sand much more than is standard practice. We feel that, in every respect, the results obtained from these filters composed of clean sand were surprisingly good and may prove of general interest. This paper will attempt to give an account of the results obtained and methods employed.

A complete description of the Detroit Experimental Plant and experimental operating technique employed has been included in another paper (Two Years' Operation of Experimental Sedimentation Basin at Detroit, Mich.). It may be well to repeat here that the plant comprised two complete units, subsequent to the chemical treatment and mixing chamber processes, these being common to both. The water applied to Filter No. 1, the control, came either from a sedimentation basin of constant dimensions, or direct from the mixing chamber through a by-pass flume. Filter No. 2, the variable unit, took water from a sedimentation basin the size of which was

varied for the different experiments. The dimensions of both filter units were 4 by 7½ by 9 feet, the sand area being 30 square feet. They were operated continuously, night and day, over a two year period at a constant rate of 160 m.g.a.d. During the greater part of this period three runs were made each day, six hours in length, one on each 8 hour shift. The sand size and grading were alike in both filters, and the same as that used in the main plant. Effective sand size was 0.55 mm. and uniformity coefficient 1.35. The sand depth was 27 inches and free board 34 inches.

I. Advantages of clean filter sand

1. *Experience at the Detroit Experimental Plant.* Within a few months after the experimental plant was put in operation in January, 1927 the two filter beds began to show sand shrinkage, disclosed by deep, wide cracks along the side walls. This condition grew steadily worse until the sand was finally cleaned in both units during August, 1927. By that time the sand grain coating amount to an average of 7 per cent by weight (referred to clean, dry sand), throughout the total sand depth. This coating consisted of a very adherent alumina and clay, gelatinous film, dark brown in color. Its composition was roughly 50 per cent alumina (Al_2O_3) and 50 per cent acid insoluble matter, such as clay and silt. The percentage of the top ½-inch layer of sand was about 17, and the average to a depth of six inches was 13. Due to this and attendant mud accumulations in the sand the condition of the beds was such as to make further progress with sedimentation studies, then under way, impossible. The experimental results were becoming more and more inconsistent, due to the erratic behavior of the filters.

Up to this time we had studiously avoided doing anything to the filter beds, fearing that any tampering with them might introduce some new and unaccounted for variable, of which there were already enough to contend with. Finally reaching the conclusion that the data then being obtained were of no value, the decision was made to clean thoroughly the two filter beds. This was accomplished without disturbing the operation of the plant, by resorting to methods of a somewhat strenuous nature. During each filter wash, while the sand was in suspension, a quarter-inch mesh, iron screen, fastened to a ten inch square, angle-iron frame and held in a horizontal position was operated up and down, like a churn, through the entire depth of the sand. This procedure was followed faithfully each time the filters were washed.

The effectiveness of this process became evident in a few weeks time. Not only did it prove successful in ridding the beds of mud balls, mud banks and loose mud, but, in addition, had cleaned the sand grains almost perfectly. The top $\frac{1}{2}$ -inch layer of sand now showed only 1.4 per cent of coating instead of the former 17. The sand surface was covered by a thin layer of dirty coagulum and mud about one-eighth of an inch thick, possibly a typical "schmutzdecke." Underneath this the sand appeared to be as clean as beach sand. Shortly after beginning agitation of the sand with the screen churn, and presumably sometime before the sand coating had been completely scoured off, we noticed that sidewall shrinkage was no longer evident. And during the seventeen months of operation that followed this shrinkage did not again appear.

The method of cleaning filter sand just described was not received enthusiastically by the operators who were obliged to manipulate the churn. And certainly such strenuous agitation was not practical for a full-sized filter unit. The decision was made, therefore, to install increased wash water facilities, so that the rate of application of the wash water might be raised. When this was done the improved hydraulic conditions made possible a washing rate of 43 inches per minute vertical rise, which resulted in a sand expansion of 16.3 inches, or 60 per cent of the thickness of the bed.

The high-expansion wash accomplished the desired result. From the time it was begun the two filters never again showed any tendency to become muddy, to collect mud-balls, or to show shrinkage cracks, and what is more striking the sand remained free from coating. When operation of the plant was discontinued the coating on the top $\frac{1}{2}$ -inch layer of sand amounted to only 1.5 per cent. Furthermore, it was gratifying to observe, during the filter washing process, that the rising wash water cleared within two minutes to such an extent that the suspended sand surface could be seen plainly through it.

We felt that possibly we were open to criticism for washing the filters so clean, and in fact were fully prepared to accept reduced bacterial efficiency as one undesirable result. This was, however, considered to be of secondary importance in the investigation then in progress. Much more important was the consistent filter performance maintained along with the clean sand, and, therefore, the high expansion wash was continued to the end of the experimental program. As it happened, bacterial efficiency was not sacrificed, as will be shown by data presented further on in this report.

2. *Relation between shrinkage and sand coating.* Admitting the observations and experience here, both in the experimental filter plant and in the large plant, are limited to sand shrinkage that manifests itself by cracking away from the filter walls, and does not include surface cracks, we desire, nevertheless, to give these observations somewhat in detail, and a theory of the cause of side wall shrinkage based upon such observations as we have been able to make.

There are several seemingly related conditions that invariably appear to accompany this shrinkage. In the first place there is the gradual but steady accumulation of the gelatinous coating on the sand grains that has been mentioned. In addition to this sand coating, those filters that show wall cracks have invariably been found to contain a wedge-shaped mound of quite solid, mud-like mixture of fine sand, coagulum and clay lying upon the top gravel layer below the place where the crack shows. The vertical face of this mound lies against the filter wall, the horizontal or bottom face rests upon, and often extends slightly into the top layer of gravel. After the filter has been washed, and drained enough so that the sand surface can be seen, the presence of this wedge of mud is betrayed by conspicuous mounding of the sand bed surface directly above it. The size and shape of the mud mound on the gravel is quite faithfully disclosed by that of the mound on the sand surface.

At the beginning of a run on such a filter, we have a number of times inserted two manometer tubes into the sand. These were screened to prevent the entrance of sand and carefully placed to the same depth, one being inserted about an inch from the wall and the other out six inches or more. Both are placed opposite a point where cracking or shrinkage has been previously observed. Any difference in the water levels in those two tubes represents the loss of head in a horizontal plane through the sand separating them. Such a loss of head does actually exist, quite small at the start of the run, but steadily increasing, and often amounts to a foot or more between the tubes when the final filter loss of head is 8.5 feet. The shrinkage bears a direct relation to this loss of head, increasing as the loss of head increases.

Putting these observed facts together one may arrive at what seems to be a plausible explanation of the cracking phenomenon. First assume that no matter how the mud shelf is started originally, its continued presence must indicate a poorly distributed wash. And

since the system that distributes the wash water is the same one that collects the filtrate, it follows that the downward flow of water through the sand during filtration is also not uniformly distributed. This is substantiated by the observations with the two tubes, the one close to the wall always showing the greater pressure. This pressure difference indicates a horizontally directed flow of water away from the filter wall, with a resultant force acting upon the sand grains and tending to move them in the same direction. If the sand so acted upon is backed up by some rigid body that will present a reactive force no motion can take place. A body of clean sand with compact grains presents such a rigid backing, and, therefore, a filter bed of clean sand will not shrink appreciably, even if the direction of water flow through it may vary somewhat. But, on the other hand, sand grains covered with a plastic, moist, gelatinous coat that is compressible, are not rigidly fixed, and cannot effectively resist pressure from neighboring grains. Closer squeezing together of the grains in the direction of water flow can, and does take place, as witnessed by the shrinkage away from the wall, increasing as the flow of water in that direction increases.

It is our present belief that these two conditions must both be present before side wall shrinkage can occur, viz., coated filter sand and poorly distributed flow through the filter. Other investigations in progress here may possibly modify this conclusion. To date, however, we can quite definitely state the following observations: (1) when the filter sand is heavily coated and mud mounds are present shrinkage occurs; (2) that a filter composed of heavily coated sand, but with all mud accumulations removed and prevented from reforming by a sufficiently high velocity wash, does not show any shrinkage; (3) that a filter containing slightly coated sand, say 4 per cent by weight, but containing mud mounds along the walls, shrinks only slightly; and (4) that, if the filter is composed of very nearly clean sand (2 per cent of coating or less) and all mud mounds are absent, no shrinkage whatever takes place.

It appears to us from these observations that sand coating is not the cause of shrinkage, but merely makes it possible when certain other conditions are also present. It seems to us that the primary source of trouble is the filter wash.

3. *Clean sand bacterial efficiency.* Prior to our experience with clean sand in the experimental filters, we had the impression, quite generally held, that gelatinous coating on filter sand was something

very essential to make it a good, workable and efficient filtering medium. While not yet positive there is no truth in this, still we feel doubtful that there is any real necessity for more than a slight amount of coating. We are quite sure that there is such a thing as carrying this "ripening" process too far. Can anything be gained

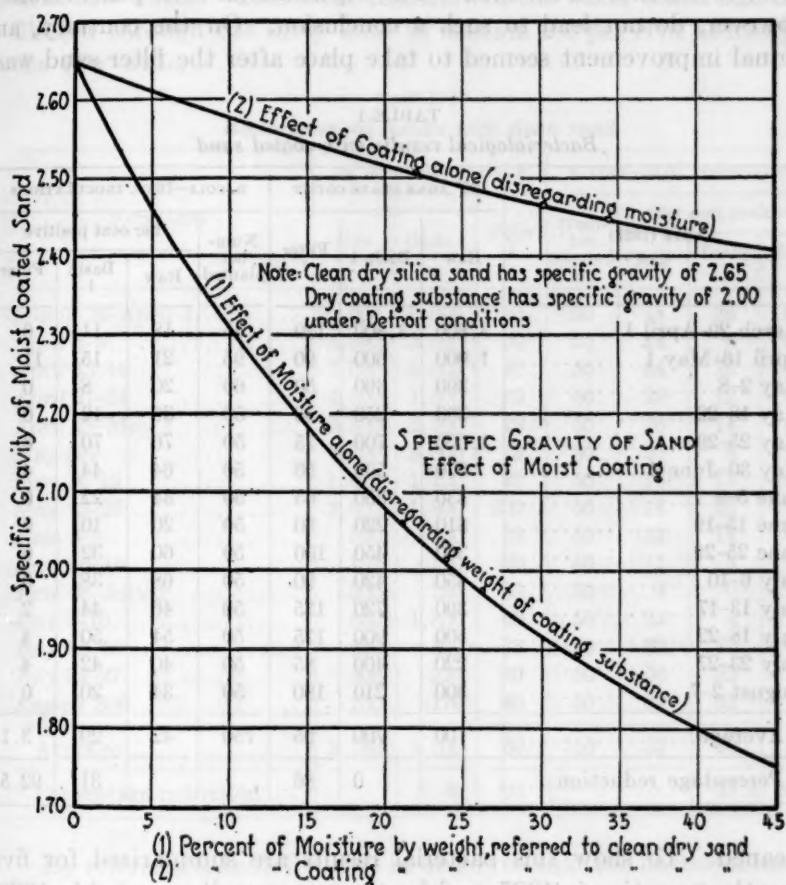


FIG. 1. SPECIFIC GRAVITY OF SAND—EFFECT OF MOIST COATING

by allowing coating substance to accumulate on the sand until it has reached 15 or 20 per cent? Why is it necessary in most plants sooner or later to discard the old, dirty filter sand and replace it with new? This must be an admission that something has happened to it to make it unfit for use. Most likely this "something" is the heavy

and obnoxious coating formed on the old sand, aggravated in time by the formation of mud balls, cemented sand, shrinkage, surface cracks and what not.

It may be possible that the accumulation of a coating or the so-called ripening of sand is a necessity if the best bacterial reductions are to be obtained from the filter. The experimental filter plant results, however, do not lead to such a conclusion. On the contrary, an actual improvement seemed to take place after the filter sand was

TABLE 1
Bacteriological results with coated sand

DATE (1927)	20° AGAR PLATE COUNT			B. COLI—10 CC. INOCULATIONS			
	Raw	Basin 1	Filter 1	Number planted	Per cent positive		
					Raw	Basin 1	Filter 1
March 29–April 1.....	3,800	3,800	120	45	18	11	0
April 16–May 1.....	1,000	600	90	95	21	15	11
May 2–8.....	390	390	50	60	20	8	0
May 18–22.....	300	250	40	50	36	12	0
May 25–29.....	1,000	700	75	50	76	70	6
May 30–June 4.....	570	500	50	50	64	44	4
June 5–9.....	330	350	65	50	34	22	0
June 15–19.....	310	220	80	50	20	10	0
June 25–29.....	360	450	100	50	60	32	0
July 6–10.....	450	420	90	50	68	38	0
July 13–17.....	390	720	135	50	46	44	2
July 18–22.....	500	900	175	50	54	50	4
July 23–27.....	220	400	85	50	40	42	4
August 2–7.....	300	210	180	50	34	20	0
Average.....	700	700	95	750	42	29	3.1
Percentage reduction.....		0	86			31	92.5

cleaned. To show this bacterial results are summarized for five months operation in 1927, and for the corresponding period in 1928. The comparison is made by tables 1 and 2. The data are for Filter No. 1, which in 1927 contained heavily coated sand, while during the corresponding months in 1928 the sand in it was clean. The reason for choosing this particular filter was because, as the control, it always took water from a settling basin of constant volume. Mixing time and alum dosage were the same for both years. In 1928 this filter took water directly from the mixing chamber half the time, explaining why the data include only every other experiment.

To summarize the results given in tables 1 and 2: the 20 degree agar counts show an average removal of 98 per cent for the clean as against 86 for the dirty sand. With reference to *B. coli*, the positive and confirmed 10 cc. inoculations with water which had passed through the clean sand showed only 0.5 per cent of the number found with raw water. This same test showed the water which had been filtered through the dirty sand to contain 2.6 per cent as many as the raw water.

TABLE 2
Bacteriological results with clean sand

DATE (1928)	20° AGAR PLATE COUNT			B. COLI—10 CC. INOCULATIONS			
	Raw	Basin 1	Filter 1	Number planted	Per cent positive		
					Raw	Basin 1	Filter 1
March 29–April 1.....	10,000	6,000	130	50	48	36	0
April 5–8.....	5,500	3,500	30	50	24	8	0
April 13–16.....	7,000	3,000	40	50	64	36	0
April 21–24.....	4,500	1,500	10	50	26	12	0
April 28–May 1.....	3,500	2,300	15	50	26	14	0
May 5–8.....	4,100	3,000	15	50	20	8	0
May 16–19.....	1,600	1,100	45	50	16	18	0
May 23–26.....	2,600	1,800	200	50	18	22	0
June 3–6.....	550	400	25	50	32	14	0
June 16–19.....	125	170	20	50	2	8	0
June 28–July 1.....	200	180	85	50	4	0	2
July 7–10.....	650	1,300	50	50	32	4	0
July 15–18.....	450	550	15	50	60	32	0
July 24–27.....	400	220	40	50	56	32	2
August 3–6.....	250	170	40	50	64	32	4
Average.....	2,750	1,700	50	750	32	20	0.5
Percentage reduction.....		40	98			37.5	98.4

By referring to table 3 it may be observed that the bacterial results obtained from both filter units throughout the year 1928, during which time the filters were operated with clean sand, were excellent.

4. *Effect on consistent filter performance.* The successful completion of the experimental program is due to the fact that after the sand was well cleaned the two filters began to perform in a dependably consistent manner. This they had failed to do before they had been cleaned. Two examples may be cited to show this. The initial loss of head in the filters varied with consecutive runs from 1.5

TABLE 3
Showing most probable number of *B. coli* in raw, applied and filtered waters

EXPERIMENT NUMBER	DATE (1928)	RETENTION PERIOD		M.P. NUMBER OF B. COLI PER 100 CC.						PER CENT REMOVAL OF B. COLI FILTER EFFLUENT			
		Basin 1	Basin 2	Raw	By pass	Applied water		Filter effluent of filter		No. 1	No. 2		
						No. 1	No. 2	No. 1	No. 2				
												No. 1	No. 2
January-June, 1928													
40A6	January 6-9	1.60	1.42	8		1	10	0	100	100			
40AB6	January 10-13	1.60	2.82	6		1	10	0	100	100			
40ABC6	January 13-16	1.60	4.24	210		207	35	1.2	1.0	99.5	99.5		
40ABCD6	January 17-20	1.60	5.66	17		12	90.4	0.9	98	95			
40ABCD6P	January 20-24	BP	5.64	18	7		120.2	0	99	100			
40ABC6P	January 26-28	BP	4.26	16	34		110.2	0.5	99	97			
40AB6P	January 28-31	BP	2.82	12	5		40	0	100	100			
40A6P	February 1-4	BP	1.41	14	5		70	0	100	100			
35A6	February 7-10	1.60	1.23	5		2	30	0.6	100	88			
35AB6	February 11-14	1.60	2.46	4		2	20	0	100	100			
35ABC6	February 15-18	1.60	3.69	14		6	60.4	0	97	100			
35ABCD6	February 18-21	1.60	4.93	6		10	20	0	100	100			
30A6	February 24-27	1.60	1.06	9		5	20.2	0.2	98	98			
30AB6	February 27-1	1.60	2.12	3		1	30	0	100	100			
30ABC6	March 2-5	1.60	3.17	24		24	250	0.2	100	99			
30ABCD6	March 6-9	1.60	4.22	1		1	10	0	100	100			
30A4	March 17-20	1.60	0.72	4		2	20	0	100	100			
30AB4	March 22-25	1.60	1.44	1		1	00	0	100	100			
30AB4P	March 25-28	BP	1.44	1	1		10	0	100	100			
30ABC4	March 29-1	1.60	2.16	270		28	100	0	100	100			
30ABC4P	April 1-4	BP	2.14	34	8		20.2	0.2	99	99			
30ABCD4	April 5-8	1.60	2.83	3		1	10	0	100	100			
30ABCD4P	April 8-11	BP	2.83	10	9		30.2	0	98	100			
35A4	April 13-16	1.60	0.82	273		245	280	0.4	100	99.9			
35A4P	April 17-20	BP	0.82	4	3		30.2	0	95	100			
35AB4	April 21-24	1.60	1.64	4		1	10	0	100	100			
35AB4P	April 24-27	BP	1.64	2	1		10	0	100	100			
35ABC4	April 28-1	1.60	2.47	8		2	20	0	100	100			
35ABC4P	May 1-4	BP	2.47	3	2		20	0	100	100			
35ABCD4	May 5-8	1.60	3.29	3		1	10	0	100	100			
35ABCD4P	May 8-11	BP	3.29	2	3		10	0	100	100			
40A4	May 16-19	1.60	0.94	4		2	20	0	100	100			
40A4P	May 19-22	BP	0.94	4	12		30	0	100	100			
40AB4	May 23-26	1.60	1.88	2		3	10	0	100	100			

TABLE 3—Continued

EXPERIMENT NUMBER	DATE (1928)	RETENTION PERIOD		M.P. NUMBER OF B. COLI PER 100 CC.						PER CENT REMOVAL OF B. COLI FILTER EFFLUENT	
		Basin 1	Basin 2	Raw	Applied water		Filter effluent of filter		No. 1	No. 2	
					By pass	Settled in basin					
						No. 1	No. 2	No. 1			No. 2

January-June, 1928—Continued

		hrs.	hrs.								
40AB4P	May 27-30	BP 1.88	3	6			10.2	0	93	100	
40ABC4	June 3-6	1.60 2.82	4		3	20	0	100	100		
40ABC4P	June 7-10	BP 2.82	7	6		30.6	0	91	100		
40ABCD4	June 20-23	1.60 3.76	1		0	00	0	100	100		
40ABCD4P	June 16-19	BP 3.76	1	1		10	0	100	100		
45A4	June 28-1	1.60 1.06	1		0	10.2	0	50	100		
45A4P	July 2-5	BP 1.06	1	1		10	0	100	100		
45AB4	July 7-10	1.60 2.11	7		1	10	0	100	100		

July-December 1928

45AB4P	July 10-13	BP 2.11	9	4		40.2	0.2	98	98		
45ABC4	July 15-18	1.60 3.16	35		5	40	0.2	100	99		
45ABC4P	July 19-22	BP 3.16	10	12		40.2	0.2	98	98		
45ABCD4	July 24-27	1.60 4.25	12		4	70.2	0.9	98	92		
45ABCD4P	July 28-31	BP 4.25	39	20		70.4	0.2	99	99		
45A4X	August 3-6	1.60 1.06	10		10	50.5	0	95	100		
45A4XP	August 6-11	BP 1.06	13	18		18 1.1	0.8	92	94		
45A3	September 5-8	1.60 0.79	14		35	63 0.7	0.4	95	97		
45A3P	September 9-12	BP 0.79	6	30		94.2	0.6	33	90		
45AB3	September 14-17	1.60 1.58	10		7	26 0.2	0	98	100		
45AB3P	September 17-20	BP 1.58	10	13		60.5	0	95	100		
45ABC3	September 22-25	1.60 2.36	41		35	39 0.7	0.5	98	99		
45ABC3P	September 25-28	BP 2.37	45	15		16 0.2	0.2	99	99		
45ABCD3	September 30-3	1.60 3.16	36		30	70.0	1.5	100	96		
45ABCD3P	October 9-12	BP 3.16	8	81		80	0	100	100		
40A3	October 3-7	1.60 0.70	30		7	100	0	100	100		
40A3P	October 13-16	BP 0.70	8	10		90.7	0	92	100		
40AB3	October 18-21	1.60 1.40	14		12	90	0.2	100	98		
40AB3P	October 21-24	BP 1.41	26	72		36 0.2	0.2	99	99		
40ABC3	October 26-29	1.60 2.10	350		22	850	0	100	100		
40ABC3P	October 29-1	BP 2.10	38	41		60.2	0	99	100		
40ABCD3	November 3-6	1.60 2.80	48		14	140.5	0.2	99	99		
40ABCD3P	November 6-9	BP 2.80	13	11		40.2	0	98	100		
35A3	November 12-15	1.60 0.61	20		6	50	0	100	100		

TABLE 3—*Concluded*

EXPERIMENT NUMBER	DATE (1928)	RETENTION PERIOD		M.P. NUMBER OF B. COLI PER 100 CC.						PER CENT REMOVAL OF B. COLI FILTER EFFLUENT			
		Basin 1	Basin 2	Raw	Applied water		Filter effluent of filter		No. 1	No. 2			
					By pass	Settled in basin	No. 1	No. 2					
											No. 1	No. 2	
July–December, 1928—Concluded													
35A3P	November 16–19	BP	0.61	48	39		35	0.5	0	99	100		
35AB3	November 19–22	1.60	1.22	27		21	17	0.2	0.2	99	99		
35AB3P	November 23–26	BP	1.22	353	114		66	0.9	0.2	99	99		
35ABC3	November 27–30	1.60	1.83	52		21	20	0.2	0.2	99	99		
35ABC3P	December 4–8	BP	1.83	100	112		37	0.2	0.2	99	99		
35ABCD3	December 8–11	1.60	2.44	135		40	43	0.2	0.2	99	99		
35ABCD3P	December 1–4	BP	2.44	47	42		19	0.4	0.2	99	99		
30A3	December 13–16	1.60	0.52	33		5	7	0	0	100	100		
30A3P	December 17–20	BP	0.52	39	39		11	0.2	0.2	99	99		
30AB3	December 20–23	1.60	1.04	312		66	93	0	0.2	100	99		
30AB3P	December 24–27	BP	1.04	301	24		36	0.2	0.2	99	99		
30ABC3	December 28–31	1.60	1.56	40		37	14	0.2	0	99	100		
30ABC3P	January 1–3	BP	1.56	11	4		4	0	0.2	100	99		
30ABCD3	January 4–7	1.60	2.08	6		2	2	0	0	100	100		
30ABCD3P	January 8–11	BP	2.08	4	6		5	0	0	100	100		
Average M.P.N. of B. Coli. 100 cc.						42	23	21	12	0.22	0.14	97.5	99.0

M.P.N. shown is the average of 10 samples, 5–10 cc., 1–1 cc., and 1–0.1 cc. each sample.

to 2.5 feet; after cleaning the sand this loss assumed an almost constant value of 1.0 to 1.1 feet. Prior to cleaning the sand the loss of head curves were very irregular, wavy lines; afterwards they became almost straight lines. These loss of head graphs were plotted for every run, and we learned to depend upon them, for a glance at them served to show the status of filter operation. When any irregularity appeared in the graph the cause of this was sought and usually found to be some minor trouble, such as variations in rate control, entrapped air in the loss of head tubes, or some other easily remedied condition.

These loss of head graphs for the individual runs when plotted as a cumulative curve for, say, ten consecutive runs in the same experi-

ment, were likewise nearly straight lines. Figure 2 is appended to show this. The four graphs comprising figure 2 picture the twenty consecutive runs of two experiments (45AA6 and 45AP6) with the two filters operating in parallel. During both experiments the filters were each washed every six hours, or twenty times in all, yet it is not easy to detect by any breaks or irregularities in the curve, where the runs ended.

5. *Effect of coating on sand rise during washing.* Prior to cleaning the experimental filters some sand always floated out of them during

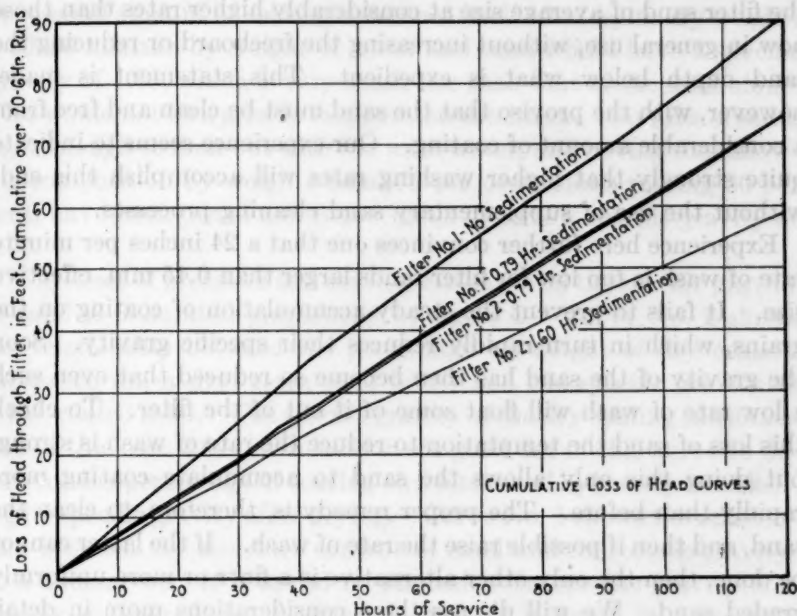


FIG. 2. CUMULATIVE LOSS OF HEAD CURVES

the wash. The rate of wash used at that time was 28 inches per minute vertical rise, and the effective size of the coated sand was 0.55 mm. After cleaning the sand it was perfectly evident that no grains floated up even close to trough level. Previously, when watching the coated sand float out we had always felt inclined to reduce the rate of wash, but somehow resisted the temptation, but now with the clean sand level remaining well below the troughs it was apparent that the wash rate could even be increased considerably without danger of losing any sand. In hope that an increased rate would enable us to keep the sand clean, a much larger wash water feed line

than the one in use was installed. This gave a wash rate of 43 inches per minute vertical use.

The first measurements made in January, 1928, with the wash water temperature 33°F., showed that this increased rate gave (Filter No. 1) a sand expansion of 16.3 inches, or based upon the drained sand (26.9), sixty per cent. The freeboard in this filter being 34.5 inches, it is apparent that even this unusually high rate of wash raised the expanded sand surface only half way to trough level.

We are satisfied that these results show that it is possible to wash the filter sand of average size at considerably higher rates than those now in general use, without increasing the freeboard or reducing the sand depth below what is expedient. This statement is made, however, with the proviso that the sand must be clean and free from a considerable amount of coating. Our experience seems to indicate quite strongly that higher washing rates will accomplish this end, without the use of supplementary sand cleaning processes.

Experience here further convinces one that a 24 inches per minute rate of wash is too low for filter sands larger than 0.45 mm. effective size. It fails to prevent the steady accumulation of coating on the grains, which in turn rapidly reduces their specific gravity. Soon the gravity of the sand has then become so reduced that even such a low rate of wash will float some of it out of the filter. To check this loss of sand the temptation to reduce the rate of wash is strong, but doing this only allows the sand to accumulate coating more rapidly than before. The proper remedy is, therefore, to clean the sand, and then if possible raise the rate of wash. If the latter cannot be done, then the only other alternative is a finer or more uniformly graded sand. We will discuss these considerations more in detail later, under "Relation of Sand Expansion to Successful Filter Washing."

The effect of coating upon the specific gravity of sand cannot be too strongly emphasized, as one of the most important factors among the several that affect the equilibrium of the sand particle during backwash. Having devoted some time to the study of this phase, we wish to call attention to a few of the things learned so far.

Alumina coating on filter sand is a colloidal, jelly-like substance capable of holding an enormous amount of water in proportion to its own weight. Like a sponge, it is itself very light, but can absorb many, many times its own weight of water. Furthermore, like an alumina cement it has great adherent properties and tenaciously

bonds with the sand grain. Once formed upon the sand it clings to it and becomes an integral part of it. This absorbent coating has the effect of greatly increasing the total volume occupied by the particle, without adding materially to its weight. The new particle, therefore, that is the coated sand, has a specific gravity much less than that of its sand nucleus. This is governed by the amount of coating. The extent to which the specific gravity of the sand is affected may easily be determined. The specific gravity of clean sand is 2.65, and that of water, 1.00. Disregarding the effect of the very small amount of coating substance itself (that is, its dry weight) a 50-50 mixture by weight of water and sand would have a specific gravity of 1.45, which is very much less than that of the sand alone. This would not be a greatly exaggerated condition. Samples of sand, light enough to float out with the wash water, and having the following composition by weight: Sand 70 per cent, moist coating 30 per cent, have been tested and found by us to have a specific gravity of 1.77.

The effect of moisture and coating substance on the specific gravity of sand is illustrated graphically by figure 2. Curve No. 2 shows the relationship between the percentage by weight of dry coating substance (on a dry, clean sand basis) and the specific gravity of dried, coated sand. The specific gravity of the dry coating substance was in this case 2.00. We have made good use of this curve to determine the percentage of coating on a filter sand by merely establishing its specific gravity after drying. Curve No. 1 shows the relationship between the moisture content of sand and its specific gravity. In a similar way it is useful to determine the specific gravity of a heavily moisture-laden filter sand, such as is found in a recently drained bed. The direct specific gravity determination of such a sample of sand offers some difficulties, but by means of this curve it may be read, after the moisture determination has been made. Readings so taken from this curve are substantially accurate, since the change in gravity caused by the coating substance itself is quite negligible in comparison to that caused by the water it retains. This latter point, that is, the relative effect of moisture and the coating substance on the specific gravity of the sand is shown by the relative slope of the two curves.

Tables 4, 5, 6 and 7 are composed of data obtained from laboratory tests on samples of coated sand taken from rapid sand filters. As will be observed from the data of table 6 these sands were fully "ripened"

TABLE 4
Duration of moisture retention—coated filter sand compared to clean sand

TIME OF DRYING AT ROOM TEMPERATURE	PER CENT MOISTURE REMAINING	
	Coated sand	Clean sand
1 hour	24.1	7.20
1 day	17.3	6.48
2 days	17.0	5.65
3 days	16.7	4.62
6 days	15.7	

TABLE 5
Reduction in specific gravity of coated filter sand caused by retention of moisture

SOURCE OF SAMPLE	PER CENT MOISTURE	SPECIFIC GRAVITY	
		Determined	Theoretical
Filter A—Top $\frac{1}{2}$ inch	6.2	2.43	2.42
Filter B—Top $\frac{1}{2}$ inch	13.2	2.23	2.22
Filter C—Top $\frac{1}{2}$ inch	15.5	2.17	2.17
Filter D—Top $\frac{1}{2}$ inch	18.5	2.12	2.11
Filter E—Top $\frac{1}{2}$ inch	19.6	2.10	2.09
Filter F—Top $\frac{1}{2}$ inch	20.6	2.07	2.07
Filter H—Trough	39.3	1.82	1.81
Filter I—Trough	44.3	1.76	1.76

TABLE 6
Moisture retained by coated filter sand is proportional to the per cent of coating substance

SAMPLE NUMBER	PER CENT OF MOISTURE*	PER CENT OF COATING*
1	20.1	12.4
2	17.2	10.8
3	16.1	9.5
4	12.8	7.4
5	12.7	6.5
6	10.7	3.7
7	8.7	3.1
8	8.4	2.8

* Per cent of moisture is referred to dry, coated sand; per cent of coating is referred to clean, dry sand.

or coated; and the results shown in all four tables serve to substantiate statements made in preceding paragraphs.

6. *Clean sand and wash water consumption.* The question may arise as to what amount of wash water was necessary to keep the experimental filter sands clean. The answer according to our closest estimate is about 4 per cent. Each minute of wash at the 43 inches per minute rate used 810 gallons. An average of 28,000 gallons were filtered in the six hours between washes. Eight hundred and ten divided by 28,000 gives 2.8 per cent of wash water per minute. At this rate of washing the water had usually cleared within $1\frac{1}{2}$ minutes to the extent that the sand surface could be seen plainly.

TABLE 7

Reduction in specific gravity of filter sand caused by coating with a substance of specific gravity of 2.0

SOURCE OF SAMPLE	PER CENT COATING	SPECIFIC GRAVITY	
		Determined	Theoretical
Filter H—Trough.....	15.7	2.54	2.540
Filter D—Surface.....	12.9	2.56	2.557
Filter F—Surface.....	12.4	2.56	2.560
Filter E—Surface.....	11.3	2.57	2.568
Filter C—Surface.....	10.0	2.58	2.577
Filter B—Surface.....	9.3	2.58	2.583
Filter A—Surface.....	1.4	2.64	2.639

By using such an appreciably higher rate of wash in comparison to that generally employed, the time required for washing could possibly be reduced proportionately, and this may even in turn reduce the percentage of wash water necessary. This question, however, not being within the province of investigations carried on at the experimental plant, has not been considered by us.

7. *Additional advantages of clean sand.* It is not necessary to draw upon one's imagination to find other good reasons for making clean sand appeal to filter men. We will merely mention some of these without going into any discussion of them. (a) Initial filter loss of head is reduced by $\frac{1}{2}$ to 1 foot, and the available operating head correspondingly increased. (b) The moist coating on most filter sands is putrescible. That anaerobic decomposition processes sometimes take place in old sand filter beds is indicated by the putrefactive odors above such filters when drained. When sealed in an

air-tight jar such sand turns black. This simple test is quite convincing.

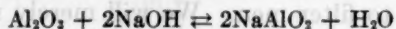
Clean sand makes a favorable impression on visitors, who are prone to notice and often comment upon a muddy appearing filter bed.

II. A method of removing coating from old filter sand

To point out or argue the advantages of clean filter sand is one thing, to clean a filter composed of dirty sand and keep it clean is another. Inasmuch as we have succeeded here in working out an economical and practical method of cleaning old sand in the filter, a description of it may be worth while. The process does not require the sand to be shoveled out or ejected from the filter, but can be carried out with the sand in place. It has so far been used very successfully in nine of the large filters, each containing 100 yards of sand, and no reason is apparent to us why it could not be used with equal success in any filter plant similarly equipped.

1. *Treatment with lye solution.* Some alumina is dissolved from the coating on filter sand by treatment with a solution of caustic soda or lye. The solution is made up on top of the sand, by first spreading lye flakes on the drained sand surface, and then opening partly the wash water valve and allowing the water to rise to a height at which the concentration of the solution becomes about 2 per cent. Spread evenly over a sand area of 500 square feet a 400 pound drum of lye flakes dissolved in eight inches depth of water gives approximately this concentration. When the lye has dissolved the solution strength is made uniform over the entire area by stirring the liquor with a paddle or some similar tool. The solution is next drawn down to about one half its original depth by opening the waste valve slightly, and is held at this level for about 24 hours. At the end of this period the depth of the solution is reduced again, this time bringing the level down to the surface of the sand, in which position it is held for an additional 24 or 48 hours.

In theory, according to the equation:



80 grams of caustic soda is equivalent to 102 grams of alumina. The reaction, however, is a reversible one, and from experiments made in the laboratory we found that it only goes to about 22 per cent completion (left to right) in 24 hours, and to about 30 per cent in 72 hours. Hence, it appears that the caustic solution is not very

efficient as a solvent for alumina. However, it accomplishes one important result, that is, it dissolves a sufficient amount of the alumina to honeycomb the coating and make it easier to remove by a subsequent scouring process. We have found that lye solutions stronger than 2 per cent are less efficient in practice, and therefore do not pay. There are other solvents for alumina that are more efficient than soda lye, such as hydrochloric acid (a 2 per cent solution of HCl will dissolve 72 per cent of the theoretical Al_2O_3 in 24 hours), but are open to objections which make their use impractical.

2. *Removing coating by high pressure hose scour.* By contact with the lye solution some alumina is dissolved from the sand grain coating, which thus becomes honeycombed, sufficiently softened and loosened as to be quite readily scoured off the sand by a stream of water played through the bed. The procedure is as follows: The spent lye solution is washed out of the sand by the ordinary filter wash, the filter drained and the waste valve left open. A strong jet of water, such as that from a half inch fire nozzle under pressure, is now played into the surface of the drained sand to a depth of 8 to 12 inches. This bombardment of the sand effectively serves to scour off the coating. The jet is used to cut a trench of convenient width, the top sand layers being broken up and thrown out by the velocity of the water stream. The entire sand surface is covered in this manner, and by the use of a $1\frac{1}{2}$ -inch hose and fire nozzle, connected to an 80 pound pressure line an area of 1000 square feet can be covered in about three hours. This process should in no event be hurried, since the object is to scour thoroughly all the sand grains in the surface turned up.

The first hosing completed, the filter is well washed, drained, and the sand then given a second hose wash. The previous filter wash has brought up coated sand from the deeper layers of the bed, as yet untouched by the hose stream. This must also be scoured, and to cover all the coated sand in the filter at least three of the hose applications are necessary. The more of these given after the lye treatment, the cleaner the sand. Tests of samples taken from the top six inch sand layer showed that one lye treatment followed by three hosings reduced the percent of coating to about 5, from the original 12 to 15 per cent. Below the surface six inch layer the grains are almost entirely free from any coating. The data of table 8 show the average per cent of coating remaining on the top six inch

layer of sand after each wash, and for eight large filters cleaned by this method.

The water passing out through the waste valve while the hose washing is in progress is so extremely muddy as to furnish convincing proof of the effectiveness of this process. The washes given after each hosing are likewise muddy, and in the decreasing turbidity of the wash water we have a very good indication of the cleanliness of the sand.

3. *Cost estimate.* On the basis of results obtained here the cleaning process costs approximately one cent per pound of dry coating substance removed. The filters contain about 100 cubic yards of sand, which has been cleaned to the extent shown in table 8 at a total cost

TABLE 8
Average per cent coating on top 6 inches of sand by specific gravity

FILTER NUMBER	ORIGINAL PER CENT COATING	REMAINING AFTER ONE LYE TREATMENT PLUS HOSE WASHES, NUMBER AS FOLLOWS					TWO LYE TREAT- MENT PLUS HOSE WASHERS	
		First	Second	Third	Fourth	Fifth	First	Second
48	15.3	7.6	7.6	6.6				
51	15.0	6.3	5.0	5.0	4.9	3.9	2.5	2.0
53	15.0	6.5	6.5	5.3				
55	17.0	10.8	5.8	5.0				
57	12.5	6.4	5.0	4.5				
59	11.3	6.0	5.2					
61	14.7	7.4	5.5	5.0				
63	14.5	8.8	6.7	5.3				

of \$60 for each filter, including the soda lye, labor and wash water. This expense is slight compared to the cost of replacement with new sand, which for one filter would amount to not less than \$1300.

III. Relation of sand expansion to successful filter washing

The preceding sections of this paper have presented the favorable results obtained with clean sand in rapid filters and outlined a workable method of restoring old sand.

The sole function of the filter wash is to maintain the sand bed clean and always in good filtering condition. Any failure to accomplish this suggests that either the wash system in use is ill equipped to do the work it is supposed to do or that operators are not making proper use of the facilities at hand. Good design and operation both

require a full understanding of what important variables are concerned in the wash and their part in it. It is most essential that the functioning of these variables be understood, and their correlation with each other. Having studied these phases of the filter washing operation somewhat in detail, we believe that the following discussion may be of interest.

1. *Sand expansion as an index of the filter wash.* By sand expansion is meant the height that the sand surface is raised during the application of wash water to the filter. It is most conveniently expressed as "per cent expansion," because at any rate of wash the amount of expansion has been shown to be proportional to the depth of the sand layer, and the percentage of expansion is therefore independent of the sand depth.

The so-called "high velocity wash," now in almost general use, results in a certain amount of expansion of the sand bed during the wash. When referred to in the literature the wash is almost invariably designated by some given velocity or rate, such as "24 inches per minute vertical rise," and very seldom is the amount of resulting sand expansion mentioned. We have come to believe, however, that the expansion of the sand bed is the proper index of the wash, and as such has not received the attention it deserved.

The rapidity and a completeness with which the entrained dirt is driven out of the sand bed, must depend not only upon the rate of upward flow of wash water through it, but also upon the extent to which the sand layer is opened up or expanded. In fact, the latter seems to us to be the more important factor. It is the agitation of the sand grains while in suspension that loosens the dirt, and suspension of the grains requires that the bed be expanded. Freedom of passage of dirt up through and out of the sand also requires that the grains be held in suspension. Now, the amount of expansion or the height to which the sand is lifted by the wash water is not alone a function of the rate of wash water application, but depends as well upon other things, the most important of which are the temperature of the applied water and the physical characteristics of the sand, such as the size, shape and specific gravity of the grains. Obviously, reliance to give results cannot be placed upon the rate of wash alone, unless this rate has been determined with due allowance for the influence of these other factors upon the resulting expansion.

We are not prepared, however, to claim universal applicability for the expansion index. It may very well be that sands of different

characteristics require different degrees of expansion for satisfactory cleaning. But we do feel certain that sand expansion comes much closer to being the correct measure of washing intensity than does the rate of application of the wash water.

2. *What degree of sand expansion is necessary?* For any given filter it is, of course, necessary to know what per cent expansion must be used to insure perfect cleaning each time it is washed. On this question we have formed certain opinions based upon experience and observations here.

At the experimental plant a range of 50 to 60 per cent expansion was used on the filters with perfectly satisfactory results. It is possible that somewhat less than 50 per cent would have been sufficient. In the large plant an expansion of 35 per cent apparently fails to keep the sand clean throughout the year, and it is doubtful that 40 per cent will do it. In our opinion somewhere between 40 and 45 per cent is the minimum for satisfactory results. These estimates are based upon clean sand, of the size and grading used in these filters.

It is hoped that further experimental work, using some of the full sized filters in the main plant, will serve to point out what sand expansion is necessary. This work has been outlined and some progress made already. The sand in eight filters has been cleaned and is being washed in each one at the maximum available rate. This varies between 30 and 38 inches per minute rise, due to the increasing distance of the filters in this row from the wash water tanks. In time this experiment may show some interesting variations in the sand conditions of these filters, and determine whether the expansion resulting from the maximum rate of 38 inches is sufficient. In the meanwhile close check will be kept upon the sand expansions obtained through the seasons, and upon the conditions of the sand in each filter. Four other filters in the plant are equipped with different kinds of sand and these might very profitably be used to gain further information as to whether the same sand expansion, when applied to different kinds and gradings of sand, give the same results. At present one of these (Filter No. 70-Ottawa Sand) has been cleaned and the bed rebuilt so that expansions up to 100 per cent can be obtained throughout the year. It is planned to use this filter to test some of the observations made at the Experimental Plant.

3. *Measurement of sand expansion.* In connection with our work we have devised three useful implements for measurement of sand expansion.

The first is merely a block of wood 5 inches square on the end of a 10 foot iron pipe that is graduated in inches. During the wash this is allowed to settle through the suspended sand until the underside of the block comes to rest upon the gravel surface. The graduations on the scale are read at any level, horizontal surface, such as the top edge of the troughs, or the top plans of the filter wall. This will give the depth of the gravel surface at that point.

The second is a similar graduated rod, the lower end of which is bent hook-shape. On the upturned end of the hook a 50 C.P., 6 volt, electric bulb is fastened in a vertical position, and connected to a source of current. Zero of the graduations on the rod is just even with the top surface of the bulb. During a wash this improvised hook gauge is lowered slowly into the bed until the light is just barely obscured by its immersion into the suspended sand. The elevation of the surface of the sand can then be read from the graduations of the rod. The sand surface can be located with a surprising degree of accuracy by means of this simple device. A change from very evident illumination to complete obscurity of the light will be caused by about one-eighth inch vertical movement of the gauge.

The purpose of the third implement, which we call a sand expansion indicator, is to allow an operator to adjust the filter washing rate to obtain any desired sand expansion, within the limits of his wash, and maintain that expansion constant during each wash thereafter. It consists simply of a float which rides on the surface of the suspended sand, and an indicator to show the amount of vertical travel of that float. The weight of the float is adjusted so that it will just barely sink through the water, remaining at equilibrium at the sand surface. The filter operator merely opens the valve wide enough to get the desired amount of sand expansion as indicated by the upward travel of the float, and in this way is adjusting the wash for different conditions of wash water temperature, sand characteristics, etc., without even being obliged to measure the rate of wash water rise. The gauge may be made as a recording instrument that will show the time, the duration and the intensity of each filter wash.

In closing, it seems to us that filter sand should be chosen first from the standpoint of its suitability as a filtering medium. The question should then be decided as to what expansion will be necessary during the wash to keep the beds clean at all times. The wash system could then be designed to give this necessary expansion, with a proper margin of safety.

IV. Conclusions

Filter sand bed shrinkage and other attendant filter troubles in the Detroit Experimental Plant, were overcome by removing coating from the sand grains and mud accumulation from the beds.

By washing the filters at a sufficient rate to obtain 50 per cent or more expansion of the sand, coating and shrinkage were prevented permanently.

Filters composed of clean sand were found to give surprisingly good results in the removal of bacteria, and in other respects performed in the most dependable and consistent manner.

A comparatively inexpensive and workable method of cleaning old filter sand within the filter is described, and the results obtained from its use at the Detroit Plant are given.

A sand expansion index for the filter wash is urged to supplant rate of wash water rise, which has been the criterion generally employed.

PART II. A STUDY OF THE WASHING CHARACTERISTICS OF FILTER SANDS

The present day rapid sand filter plant relies upon the so-called "high velocity" wash for eliminating from the filter bed all accumulated matter removed from water filtered during the previous run. To accomplish this end quickly and economically it is necessary that the backwashing rate be high enough to open or expand the sand bed to some extent. The amount of sand expansion that takes place during the filter wash depends upon the following variables: (1) depth of the sand layer, (2) rate or velocity of wash water flow, (3) the temperature of the wash water, (4) physical properties of the sand such as size, shape and specific gravity. This report comprises a study made for the purpose of obtaining data, sufficiently accurate and inclusive, to show the relationship between these variables and the resulting sand expansion. From the data we have succeeded in deriving an empirical formula by which the necessary rate of filter wash to obtain any given sand expansion may be computed, for any given size of sand and at any given wash water temperature. The accuracy of the formula, checked against the experimental results, is very satisfactory within the range of filter sand sizes.

Reason for Experiments

Early in our work at the Detroit Experimental Plant we found that it would be necessary to maintain the two filter beds uniformly clean and free from the very evident sand diseases resulting from insufficient

wash. The muddy condition of the filters was making further progress with sedimentation studies impossible. Of necessity both filter units had to operate consistently alike when filtering the same applied water, because a comparison of the operation of the filters was to be used as a measure of the difference between two applied waters. Not until an unusually high velocity wash was tried (42 inches per minute vertical rise) was it found possible to maintain the sand in these filters free from mud accumulations, without some form of supplementary agitation. Once having determined a suitable wash rate we were desirous of keeping it uniformly effective. We realized that the wash water temperature, which was very low at that time, would rise to 70° or more during the next summer, and that this change would make the wash much less effective. In an effort to find a method whereby the wash water rate could be adjusted to compensate for this change in temperature, the degree of expansion of the sand bed suggested itself as the most logical index of the intensity of the wash. It is the final, or end-product so to speak, of all the forces operating when the wash valve on a filter is open.

Reference is quite often made in the literature on the subject to percent sand expansion during backwash, hence it seems probable that some designers and operators consider it the most suitable criterion of the wash. It has been shown heretofore that sand characteristics, wash rate and wash water temperature govern sand expansion, and in a general way the rôle that each of these factors plays. Ellms and Gettrust's well known paper on this subject ("A Study of the Behavior of Rapid Sand Filters Subjected to the High Velocity Method of Washing," *Trans. Am. Soc. C. E.*, 1916, Vol. LXXX, p. 1342) showed that the sand expansion at any given wash rate was less as the sand size increased, and that it was directly proportional to the depth of the sand layer. The paper did not touch upon the important effect of water temperature, nor give any numerical formulation of the relationship between the several factors involved. Since Ellms and Gettrust's paper no further work has been published on this subject, so far as the writers are aware. We have, however, recently seen a set of tables compiled by Allen Hazen (given in a private communication from him to A. B. Morrill) which shows the per cent sand expansion to be expected using various rates of wash, at certain water temperatures on different size of sand. These data are similar in character to those contained herein. We did not suspect that it existed until after the completion of our own work. It

has but added to our own conviction that the degree of sand expansion is the best criterion upon which to base the design of a wash water system, or the study or standardization of a system already in use.

Apparatus and methods

Description of Apparatus. The apparatus on which the experiments were performed is shown in figure 3. A pyrex glass tube, $1\frac{3}{4}$

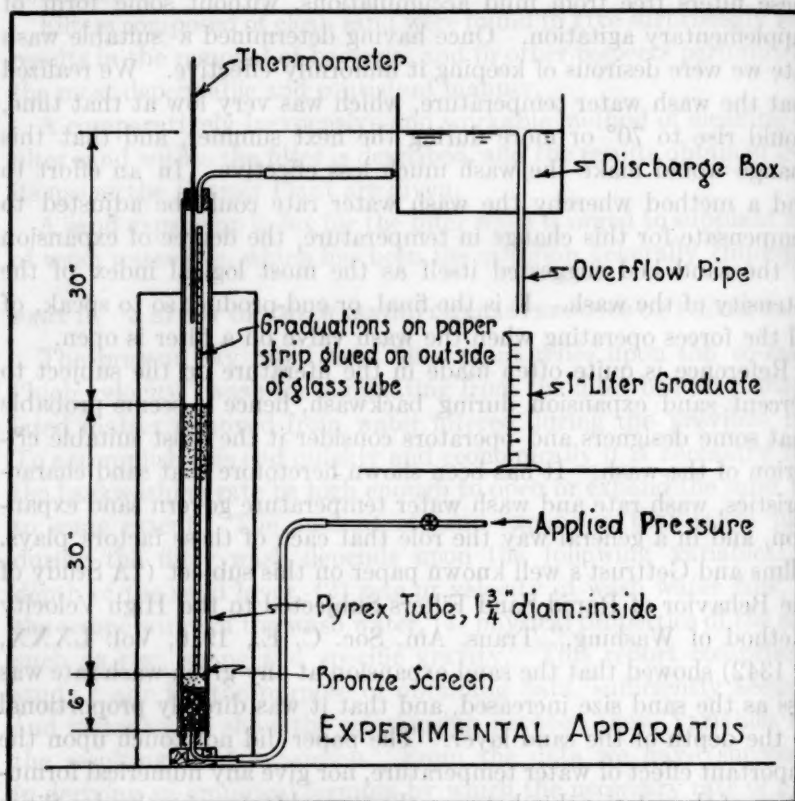


FIG. 3. EXPERIMENTAL APPARATUS

inches in diameter and 60 inches long, was used to represent a section of a filter bed. The bed of gravel was not so thick as is ordinarily used, but was found sufficient to distribute the wash water evenly, over the area. The sand and gravel were separated by a small bronze screen. The purpose of this screen was not to hold down the gravel, as the fit in the tube was not tight enough to prevent the screen from

rising with the gravel if there had been any tendency to do so: it was inserted merely to create a definite line of demarcation between sand and gravel, so as to facilitate the removal of one sample of sand and the replacement by another.

The discharge box was provided with an overflow pipe, the top of which was 30 inches above the idle sand surface. This dimension was chosen to correspond to the distance between the sand surface and the crest of the wash-water trough at the Detroit Filter Plant. The overflow was caught in a 1 liter graduate. The thermometer used was graduated to 0.2°C. Other details of the apparatus are clearly shown on the sketch.

Sands Tested. Eleven sands were tested for expansion in the apparatus. Six of these were artificially combined from an original sand furnished by the Cape May Sand Co., Cape May, N. J. After separating this original sand into its component sizes by sieving through a set of Tyler testing sieves, the sizes were recombined so as to form sands having effective sizes of 0.35, 0.40, 0.45, 0.50, 0.55, and 0.60 mm., and uniformity coefficients as close to 1.50 as possible.

The remaining five sands were samples taken from filters in the Detroit plant operating as experimental units. The filters so sampled and the trade names of the sands were as follows:

- 70—Ottawa Silica
- 72—Portage
- 74—Cape May
- 76—Northern Gravel
- 78—Red Wing

Sieve analyses of all eleven sands are shown on figures 2 and 3.

Experimental procedure. The experiments were conducted during the period from September, 1928, to January, 1929, whereby a range in water temperature of from 71° to 37°F. was obtained.

Each sample as prepared for testing was larger than necessary to fill the tube to the 30-inch height. In inserting the required amount into the tube due care was exercised that the portion selected for use would be representative of the whole. This was done by passing the entire sample through a Jones' sampler several times until the quantity obtained was less than enough to reach the 30 inch mark. This portion was then poured into the tube and the wash water turned on in order to grade the sand hydraulically. The wash water was cut off and the position to which the sand in the tube had subsided was

noted. The process of sampling was repeated until the sand column on subsiding showed a height of 30 inches. All of the original sample then remaining was discarded, and in all subsequent experiments on that sand, the quantity that had been in the tube during the first test was used again.

To remove the sand, a long glass tube, $\frac{3}{8}$ -inch in diameter, and extending down into the column of sand was inserted through the hole in the upper stopper, replacing the elbow shown in the sketch. The wash water pressure was then applied to a degree sufficient to carry the sand up the small tube and over into a gallon jar. As the sand surface lowered, during this process, the small tube was pushed down farther and farther until all the sand above the screen had been removed. The sand in the jar, after the water was poured off, was transferred to a flat tray, dried on a radiator, and set aside to be used again.

During a test, the wash water velocity was determined by measuring the amount of overflow from the discharge box during a definite time interval. In most cases this interval was one minute, except at the very high velocities when a half minute was substituted in order not to exceed the capacity of the liter graduate. From the known cross-section of the filter tube, the quantity discharged per minute was readily converted into velocity based on gross area.

The height to which the sand expanded was read directly from graduations on the outside of the tube, zero being opposite the screen at the bottom of the sand. As there was no perceptible movement of the screen during a test, the reading taken at the sand surface was the total height occupied by the column of suspended sand.

It was observed very early in the study that the position of the surface after the sand had been allowed to settle by quickly closing the wash-water valve, was not always the same. The higher the sand had been raised previous to its subsidence, the higher was the resulting idle surface. A much more constant surface level was obtained by reducing the wash-water velocity very slowly, so that the sand was never allowed to drop freely through still water, but was always supported by an upward velocity. The cause of the variability of the surface when the sand is allowed to settle freely is difficult to explain satisfactorily. One reason may be a difference between the grading when in a suspended condition and that after settling through 12 or 15 inches of water. Further, there was probably a light tendency for the falling sand to arch itself against the

walls of the tube. In any event, the slow closing of the wash-water valve simulates conditions of operation of a full size system more closely than does a sudden closure. For these reasons the base dimension upon which the amount of expansion was computed was determined by slowly decreasing the wash velocity until the sand reached a stable position.

TABLE 9
Sieve analysis of test sands

SAND	TRADE NAME	PER CENT OF SAMPLE PASSING SIEVE NUMBER								
		100	65	48	35	28	20	14	10	8
1	Cape May	0.0	0.3	8.6	47.7	87.0	97.5	99.3	99.8	100.0
2	Cape May	0.0	0.0	3.0	28.2	73.5	96.3	99.9	100.0	100.0
3	Cape May	0.0	0.0	1.0	15.8	58.3	89.9	99.6	100.0	100.0
4	Cape May	0.0	0.0	0.3	8.8	43.4	83.4	98.7	100.0	100.0
5	Cape May	0.0	0.0	0.1	3.6	31.0	72.1	97.9	99.9	100.0
6	Cape May	0.0	0.0	0.0	1.8	19.1	57.0	93.7	99.8	100.0
7	U. S. Silica	0.0	0.0	0.0	0.3	61.0	96.2	99.5	100.0	100.0
8	Portage	0.0	0.0	0.0	0.2	21.5	65.5	92.0	100.0	100.0
9	Cape May	0.0	0.0	0.0	0.3	46.5	96.2	99.5	100.0	100.0
10	Northern Gr.	0.1	0.15	0.2	0.25	7.7	53.1	94.7	99.7	100.0
11	Red Wing	0.0	0.0	0.0	0.8	43.5	86.0	98.5	100.0	100.0

Calibration of Tyler sieves

Sieve number	Size of separation, mm.
100	0.162
65	0.222
48	0.339
35	0.482
28	0.671
20	0.896
14	1.272
10	1.734
8	2.598

In practice this was accomplished by starting the test at the maximum expansion to be observed and closing the valve step by step, taking readings of sand surface and discharge at each step, until the valve was completely closed and the discharge reduced to zero. The position occupied by the sand surface at the end of the test was taken as the base. The base determined in this manner showed itself, in the series of trials to be practically constant.

Data and interpretation

Sieve analyses of sand. A careful sieve analysis was made on each of the eleven sands, using a set of standard Tyler testing sieves. These sieves had previously been calibrated by Mr. LaMarre of

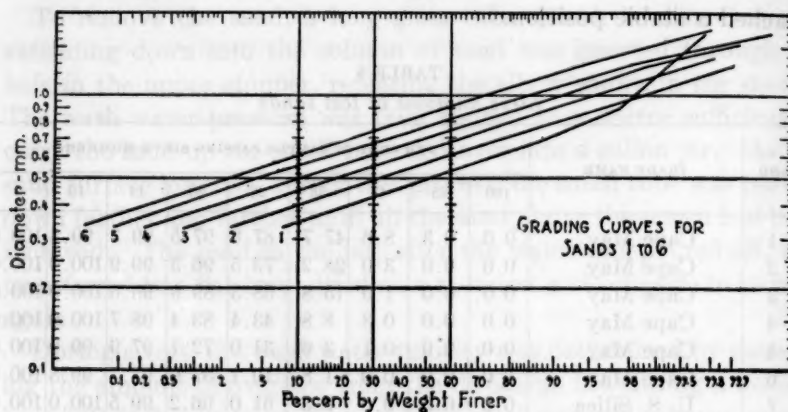


FIG. 4. GRADING CURVES FOR SANDS 1 TO 6

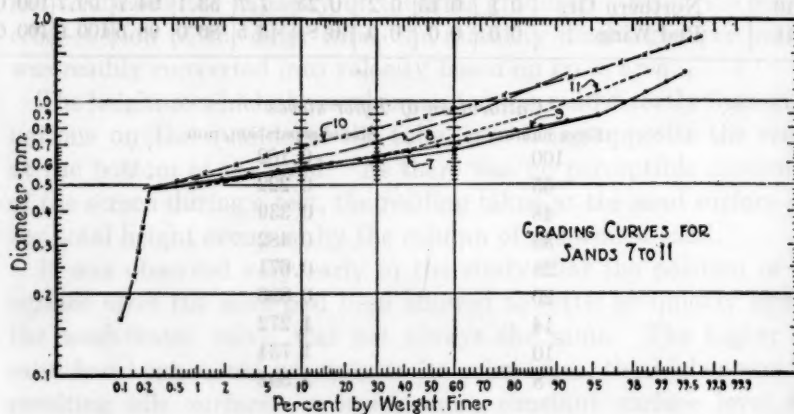


FIG. 5. GRADING CURVES FOR SANDS 7 TO 11

the Department of Water Supply, according to the method recommended by Hazen. The results of the analyses are given in tables 9 and 10, and are shown plotted on logarithmic probability paper on figures 4 and 5.

General character of results. Each test run resulted in characteris-

tic expansion curves similar to those shown on figure 6. The most interesting feature of the curve called "total height of column" is the curvature at the lower end. The curve of expansion is a straight line, intersecting, when produced, the axis of zero expansion at a rate less than 15 inches per minute. This feature agrees with the observations of Ellms and Gettrust at Cleveland.

As explained, in a previous paragraph, the points shown on the curve were obtained by starting the test at the highest expansion; in the case shown, at a total height of 48.03 inches.

Effect of sand depth. The amount of sand originally in the tube before the wash-water was applied was found to have no effect upon

TABLE 10
Size characteristics of sands

SAND	DIAMETER OF PARTICLE, MM.									UNI- FORM- ITY COEFFI- CIENT
	10 per cent smaller than	20 per cent smaller than	30 per cent smaller than	40 per cent smaller than	50 per cent smaller than	60 per cent smaller than	70 per cent smaller than	80 per cent smaller than	90 per cent smaller than	
1	0.35	0.39	0.43	0.48	0.50	0.53	0.57	0.62	0.71	1.51
2	0.40	0.45	0.49	0.53	0.57	0.61	0.65	0.71	0.78	1.49
3	0.45	0.51	0.55	0.59	0.63	0.68	0.73	0.79	0.90	1.51
4	0.50	0.55	0.61	0.65	0.70	0.74	0.80	0.87	0.97	1.49
5	0.55	0.62	0.67	0.72	0.76	0.82	0.88	0.95	1.05	1.49
6	0.60	0.68	0.73	0.79	0.85	0.92	0.98	1.06	1.20	1.53
7	0.56	0.59	0.61	0.63	0.64	0.66	0.70	0.74	0.81	1.18
8	0.62	0.66	0.72	0.76	0.81	0.86	0.93	1.04	1.20	1.40
9	0.58	0.61	0.63	0.65	0.68	0.71	0.73	0.77	0.82	1.22
10	0.68	0.74	0.79	0.83	0.87	0.93	0.99	1.07	1.20	1.37
11	0.57	0.61	0.63	0.66	0.70	0.74	0.78	0.84	0.95	1.30

the resulting expansion expressed as a per cent of the original depth. Figure 7 shows the data obtained from two samples of the same sand, one of which formed a bed 28.95 inches thick, and the other only 14.60 inches. The single expansion curve illustrates the point.

Effect of free-board. The effect of free-board, or difference in elevation between the idle sand surface and the overflow was investigated, and the plotted data are shown in figure 8. Free-board is seen to have no direct effect upon the expansion.

Sand action in tube and in filter. The action of the wash water on the sand in the experimental apparatus was compared with the corresponding action in a full size filter unit in order to determine

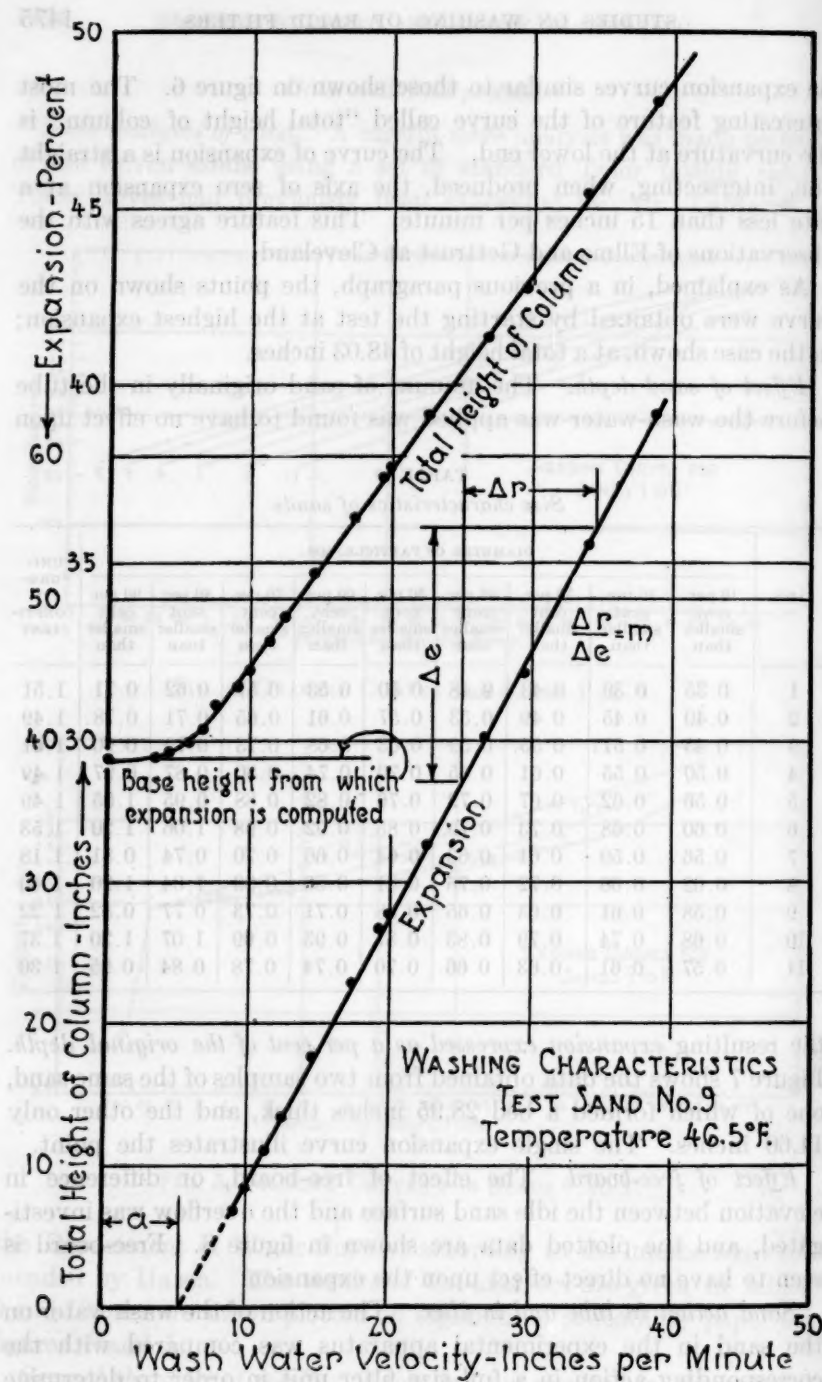


FIG. 6. WASHING CHARACTERISTICS

whether or not the results of the experiments would be directly applicable to working conditions. The sand in Filter No. 53 was very carefully sampled and tested in the tube. The action of Filter No. 53 itself was then observed and measurements of sand rise and wash water velocity obtained. It was found that the results were the same within the limits of accuracy of measurement. The two sets of data are shown on figure 9.

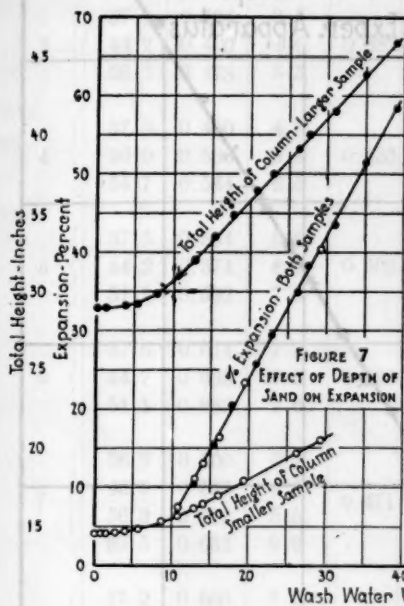


FIG. 7

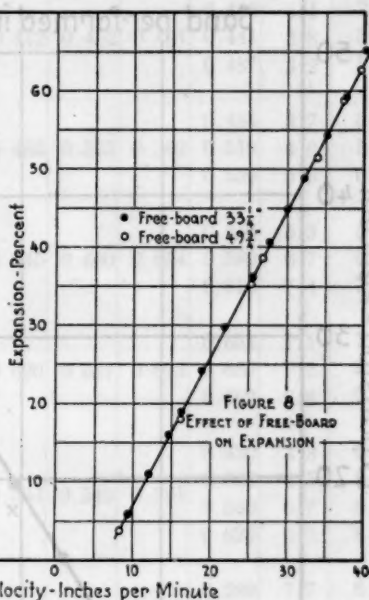


FIG. 8

FIGS. 7 AND 8. EFFECT OF DEPTH OF SAND AND OF FREE-BOARD ON EXPANSION

Presentation of data. The expansion, then, appears to be dependent on rate of wash, temperature of water, and sand characteristics only.

In presenting the data the following nomenclature will be used:

r = Rate of application of wash water, expressed in inches per minute.

e = Resultant expansion, expressed as percent of original depth.

t = Temperature of water in degrees Fahrenheit.

s = Characteristic of sand size which governs its behavior during washing.

m = Unit increase of washing rate divided by corresponding increase of expansion = $\frac{\Delta r}{\Delta e}$.

a = Intercept of expansion characteristic on axis of washing rate.

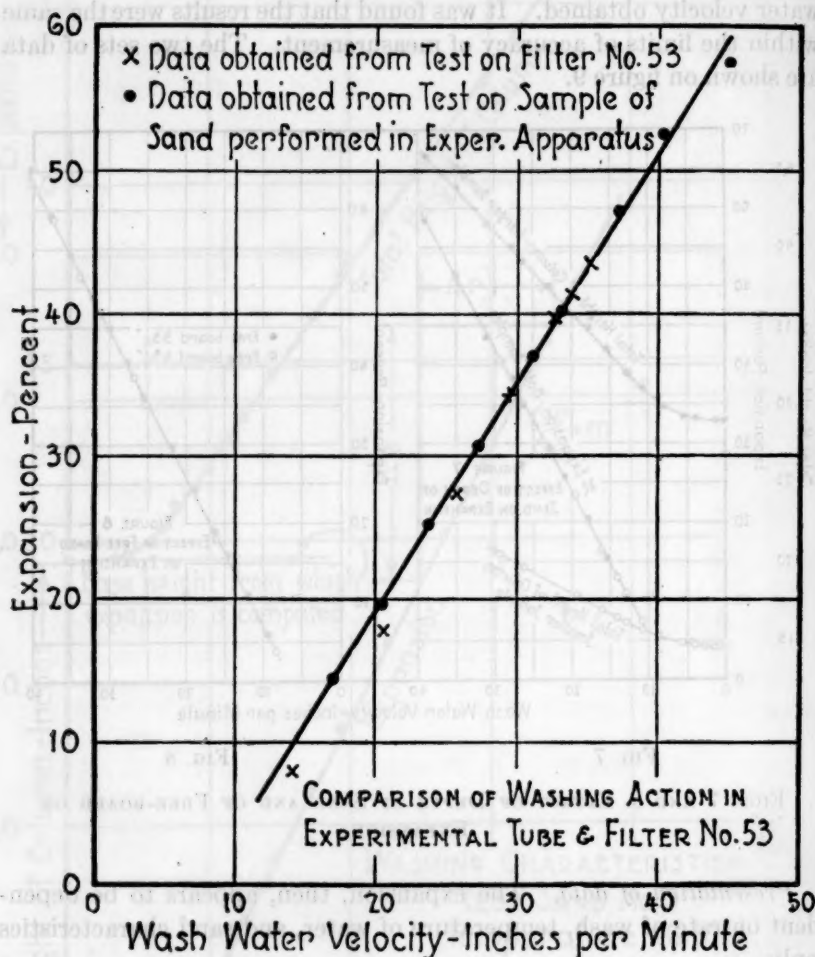


FIG. 9. COMPARISON OF WASHING ACTION IN EXPERIMENTAL TUBE AND FILTER No. 53

(The a can be interpreted as denoting the rate of wash necessary to start the expansion of the bed: and m as the additional rate necessary for each 1 per cent of expansion thereafter.)

The characteristic expansion curve is fully defined by stating the

TABLE 11
Sand expansion data

SAND (1)	<i>t</i> (2)	<i>m</i> (3)	<i>a</i> (4)	<i>m</i> ₂₂ (5)	<i>m</i> ₄₀ (6)	<i>m</i> ₅₀ (7)	<i>m</i> ₆₀ (8)	<i>m</i> cal. (9)	<i>a</i> ₂ (10)	<i>a</i> cal. (11)
1	40.1	0.290	1.5					0.292	1.7	1.4
	47.7	0.314	2.3	0.266	0.295	0.318	0.340	0.312	2.6	2.2
	58.2	0.334	3.5					0.338	3.4	3.3
2	38.6	0.344	2.4					0.355	1.9	2.1
	45.0	0.368	3.0	0.324	0.350	0.380	0.411	0.374	2.5	2.8
	58.1	0.406	4.4					0.416	4.0	4.3
3	37.9	0.404	3.5					0.418	3.1	2.9
	44.2	0.430	4.0	0.382	0.412	0.452	0.491	0.441	3.8	3.7
	56.3	0.478	5.5					0.487	5.2	5.3
4	37.8	0.480	4.0					0.484	3.7	3.9
	46.0	0.506	5.3	0.453	0.485	0.523	0.562	0.519	4.9	5.1
	54.7	0.544	6.5					0.559	5.9	6.4
5	37.5	0.534	5.9					0.550	5.3	5.3
	44.2	0.574	6.9	0.503	0.545	0.600	0.654	0.580	6.7	6.4
	51.1	0.592	7.9					0.615	7.4	7.5
6	37.6	0.614	7.3					0.621	7.1	7.0
	44.7	0.636	8.5	0.590	0.620	0.657	0.695	0.655	7.7	8.2
	51.1	0.662	9.6					0.689	8.8	9.3
7	36.9	0.500	2.7					0.480	3.3	3.8
	46.9	0.532	4.0					0.523	4.5	5.3
	56.3	0.572	5.5	0.471	0.504	0.549	0.591	0.563	5.7	6.6
	69.5	0.632	9.0					0.625	9.3	8.6
8	37.2	0.600	7.6					0.599	7.7	6.6
	43.0	0.620	8.6					0.632	8.1	7.6
	56.3	0.710	11.6	0.562	0.609	0.667	0.723	0.704	11.0	9.9
	71.0	0.776	14.8					0.787	14.7	12.5
9	38.0	0.506	4.2					0.506	4.2	4.4
	46.5	0.538	5.1					0.547	4.8	5.7
	58.2	0.598	6.8	0.481	0.515	0.560	0.604	0.598	6.8	7.5
	70.2	0.656	8.9					0.653	9.2	9.3
10	42.1	0.720	9.6					0.706	10.1	10.0
	47.7	0.740	10.5					0.744	10.7	11.1
	56.7	0.782	11.7	0.640	0.690	0.755	0.820	0.793	11.7	12.8
	70.7	0.896	14.7					0.887	14.8	15.4
11	37.8	0.520	4.5					0.506	5.1	4.4
	46.6	0.560	5.6					0.547	6.2	5.7
	59.2	0.610	7.9	0.490	0.525	0.575	0.621	0.602	8.1	7.6
	70.7	0.676	9.7					0.658	10.2	9.4

corresponding values of m and a , so it follows that, if the law of variation of these two variables with the sand size and water tempera-

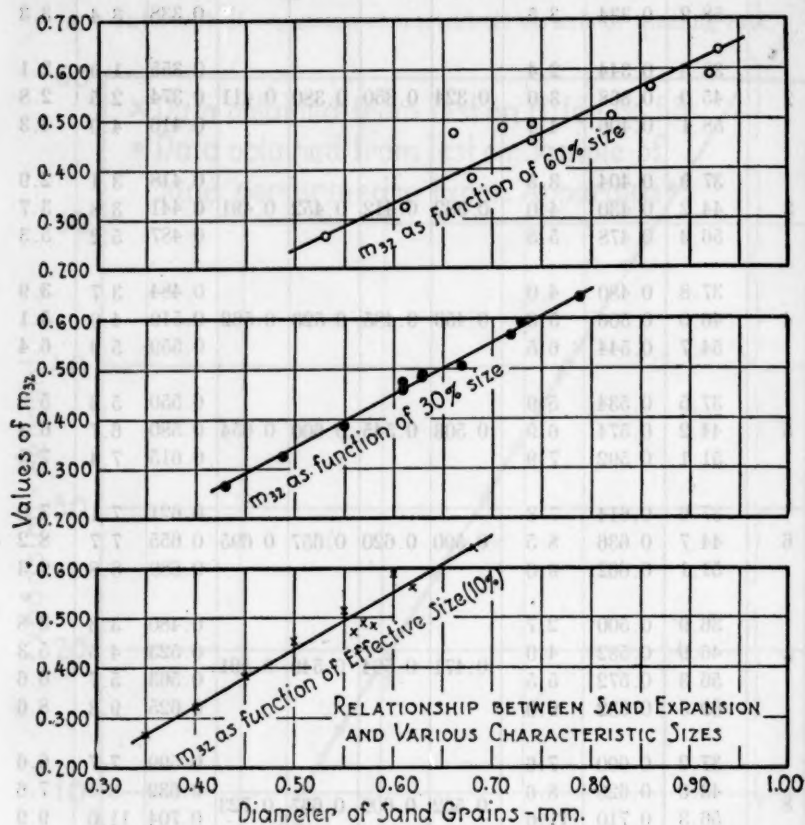


FIG. 10. RELATIONSHIP BETWEEN SAND EXPANSION AND VARIOUS CHARACTERISTIC SIZES

ture can be determined, the rate of wash necessary to obtain a given degree of expansion can also be determined from the equation.

$$r = a + me$$

The observed values of m and a are shown in columns 3 and 4 of table 11. It will be seen that the values of both these variables increase with the size of the sand and the temperature of the water.

Evaluation of data. In order to discover such a law of variation it is necessary to work with only two variables at a time. The first

step, therefore, was to evaluate m in terms of sand size under conditions of constant temperature. Interpolated values of m for temperatures of 32°, 40°, 50°, and 60° are shown in columns, 5, 6, 7, and 8 of table 3.

A study of these tabulated values in connection with the sieve analyses of the sands to which they correspond failed to reveal any consistent relationship between m and the effective size. A very close relationship, however, was discovered between m and the 30 per cent size. Figure 10 shows the values of m_{32} plotted as functions of effective size, 30 per cent size, and 60 per cent size. The 30 per cent size is seen to have a much closer relation to the expansion characteristic than either of the other two sizes.

If s is defined as the diameter such that 30 per cent of the sample by weight is smaller, the relationship between m and s can be expressed within very small limits of error as:

$$m_{32} = 1.04 (s - 0.17)$$

$$m_{40} = 1.12 (s - 0.17)$$

$$m_{50} = 1.22 (s - 0.17)$$

$$m_{60} = 1.32 (s - 0.17)$$

or in general

$$m_t = [1.04 + 0.01 (t - 32)] (s - 0.17) \dots \dots \dots (1)$$

Column 9 of table 11 shows the values of m as calculated from this expression. It will be seen that the accuracy of equation (1) is quite satisfactory. In reviewing the plotted characteristics to test calculated values, it was found that a line drawn having a value of m as calculated from (1) would represent the data as well as the line chosen originally and whose value of m is given in column 3. Accordingly these new lines were drawn in all cases and new values of a determined to correspond. These new values of a are shown in the next to last column of table 11, headed a_2 .

A treatment of these values, similar to that given the values of m , yields the following relationship:

$$a_2 = \frac{5.9}{1 - (S - 0.17)} - 7.4 + 0.2 s (t - 32) \dots \dots \dots (2)$$

The last column of table 11 shows the values of a calculated from equation (2).

Bearing in mind the expression

$$r = a + me$$

equations (1) and (2) can be combined to give

$$r = [1.04 + 0.01(t - 32)](s - 0.17)e + \frac{5.9}{1 - (s - 0.17)} + 0.24s(t - 32) - 7.4. \quad (3)$$

When this equation is applied to the observed values of r , the average error is 0.5 inch, with a maximum error of 3.0 inches.

Applicability of formula. Additional samples of sand were taken at random and their expansion characteristics were determined, in order to check the applicability of equation (3). The observed and computed values of wash water rate necessary to obtain 30, 40 and

TABLE 12
Check experiments on additional sands

	SAND—SAMPLE NUMBER					
	12	13	14	15	16	17
Effective Size, mm.....	0.48	0.62	0.53	0.40	0.40	0.36
Uniformity Coefficient.....	1.27	1.43	1.51	1.67	1.79	1.96
Sand Size, mm.—30 per cent finer than....	0.55	0.75	0.68	0.52	0.53	0.49
Temperature, °F.....	41.7	41.4	38.7	40.2	40.0	41.0
r —observed—30 per cent expansion.....	17.3	29.2	22.0	14.6	16.1	14.4
r —computed—30 per cent expansion.....	16.4	28.2	22.7	14.5	14.9	13.3
r —observed—40 per cent expansion.....	22.0	35.6	27.4	18.2	20.5	18.2
r —computed—40 per cent expansion.....	20.7	34.7	28.3	18.4	19.0	16.9
r —observed—50 per cent expansion.....	26.8	42.2	32.6	21.6	24.7	21.9
r —computed—50 per cent expansion.....	25.0	41.4	33.9	22.4	23.0	20.5

50 per cent expansions are shown in table 12. The accuracy of equation (3) was found to be quite satisfactory within the range of sands commonly used in rapid sand filters.

Use of formula. To facilitate the use of equation (3), figure 11 has been constructed. The two sets of curves show the washing rate

FIG. 11. This chart is for the purpose of determining the wash water velocity required to expand sand of a given size to the degree desired, and is based on the results of experiment. The "30 per cent size" must first be ascertained from a sieve analysis diagram similar to those on figures 2 and 3.

The data obtained from these experiments indicate that straight line interpolation can be used without material error, to determine values at temperatures other than 32° or 70°F.

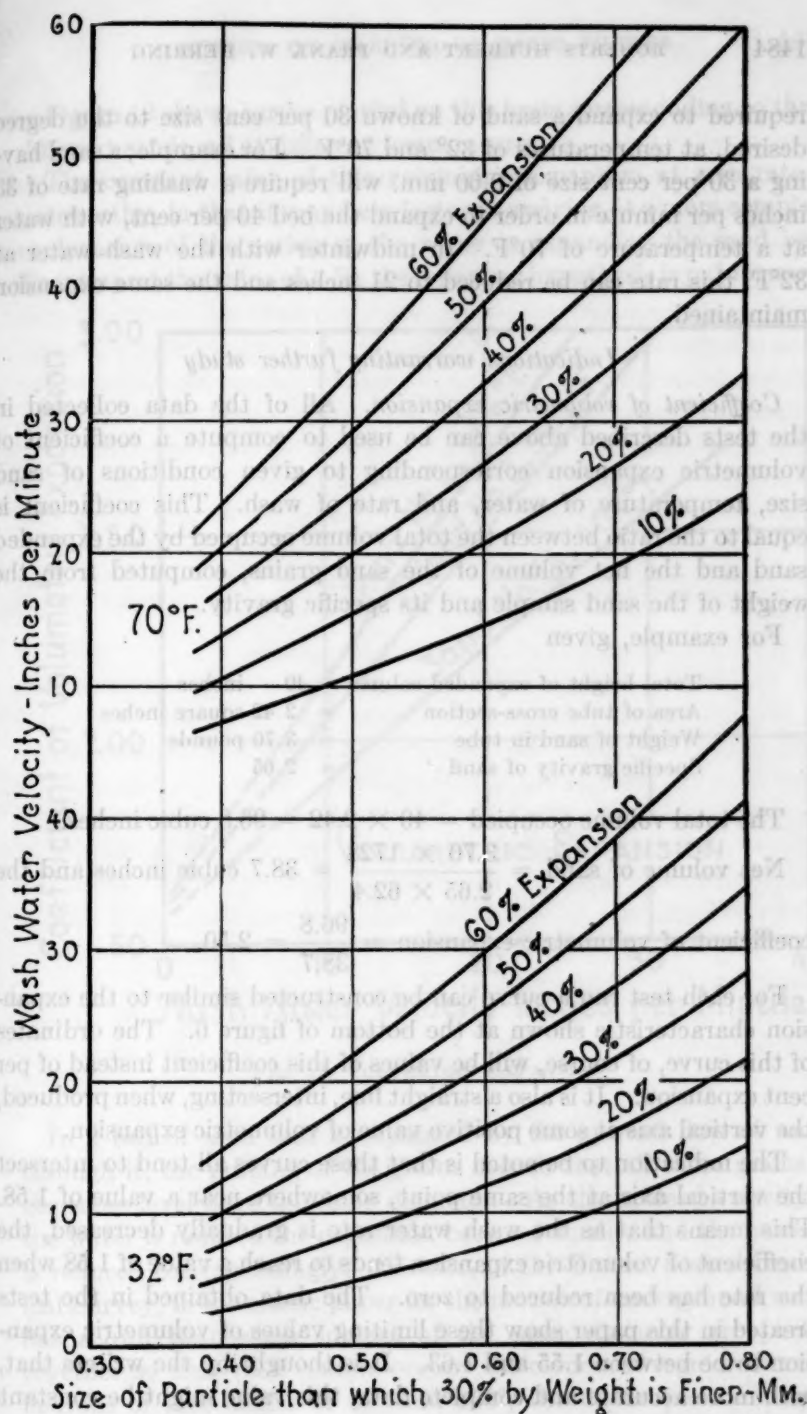


FIG. 11

required to expand a sand of known 30 per cent size to the degree desired, at temperatures of 32° and 70°F. For example; a sand having a 30 per cent size of 0.60 mm. will require a washing rate of 33 inches per minute in order to expand the bed 40 per cent, with water at a temperature of 70°F. In midwinter with the wash water at 32°F. this rate can be reduced to 21 inches and the same expansion maintained.

Indications warranting further study

Coefficient of volumetric expansion. All of the data collected in the tests described above can be used to compute a coefficient of volumetric expansion corresponding to given conditions of sand size, temperature of water, and rate of wash. This coefficient is equal to the ratio between the total volume occupied by the expanded sand and the net volume of the sand grains, computed from the weight of the sand sample and its specific gravity.

For example, given

Total height of expanded column	= 40 inches
Area of tube cross-section	= 2.42 square inches
Weight of sand in tube	= 3.70 pounds
Specific gravity of sand	= 2.65

The total volume occupied = $40 \times 2.42 = 96.8$ cubic inches.

Net volume of sand = $\frac{3.70 \times 1728}{2.65 \times 62.4} = 38.7$ cubic inches and the

coefficient of volumetric expansion = $\frac{96.8}{38.7} = 2.50$.

For each test run a curve can be constructed similar to the expansion characteristic shown at the bottom of figure 6. The ordinates of this curve, of course, will be values of this coefficient instead of per cent expansion. It is also a straight line, intersecting, when produced, the vertical axis at some positive value of volumetric expansion.

The indication to be noted is that these curves all tend to intersect the vertical axis at the same point, somewhere near a value of 1.58. This means that as the wash water rate is gradually decreased, the coefficient of volumetric expansion tends to reach a value of 1.58 when the rate has been reduced to zero. The data obtained in the tests treated in this paper show these limiting values of volumetric expansion to be between 1.55 and 1.63. It is thought by the writers that, with more accurate and complete data, this value might be constant regardless of sand size or temperature.

Figure 12 shows curves plotted on this basis corresponding to three different sands, all at different temperatures.

The constant value of this volumetric expansion at zero rate is noteworthy, in that it may be a factor in arriving at a more complete explanation of the action of the water in expanding the sand bed. To interpret the value of 1.58, the following hypothesis is put forward:

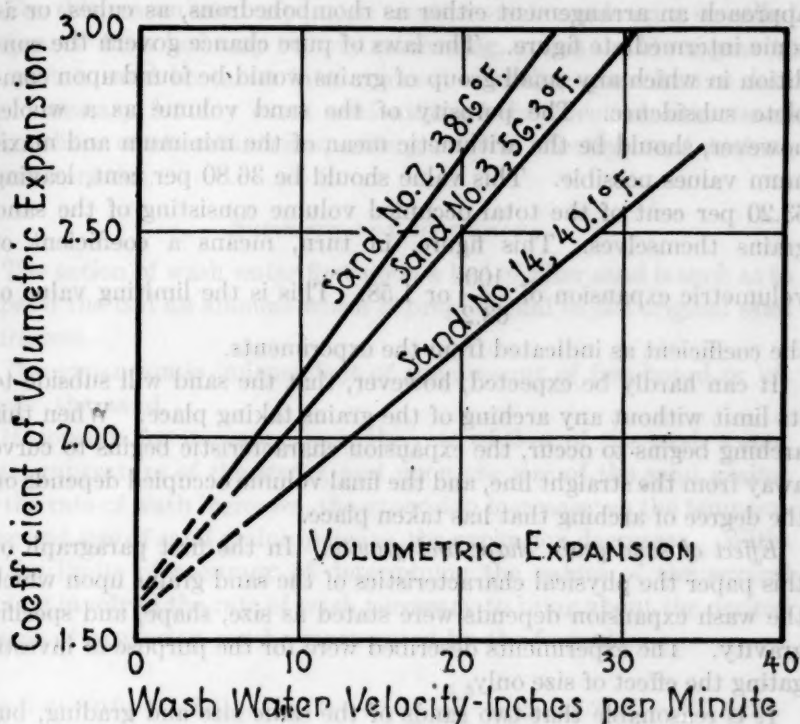


FIG. 12. VOLUMETRIC EXPANSION

In a bed of sand that is expanded by the upward flow of water through it, the grading of the grains is such that all those grains at the same level have the same diameter. As the upward velocity of the water is reduced the expansion becomes smaller and the porosity is reduced correspondingly. Slichter, of the United States Geological Survey, in his classic paper on the motion of underground water, has shown that when spheres of the same diameter are packed together so that their centers occupy the corners of regular rhombohedrons of face angles of 60° and 120° , the unoccupied volume is

equal to 25.9 per cent of the total. This is the minimum void ratio possible with spheres of the same diameter. The maximum void possible, assuming no arching of the spheres, is when they are arranged so that their centers occupy the corners of cubes. The corresponding value of the void ratio is 47.64 per cent. As the sand grains subside, due to reduction of the supporting velocity, they approach an arrangement either as rhombohedrons, as cubes, or as some intermediate figure. The laws of pure chance govern the condition in which any small group of grains would be found upon complete subsidence. The porosity of the sand volume as a whole, however, should be the arithmetic mean of the minimum and maximum values possible. This value should be 36.80 per cent, leaving 63.20 per cent of the total occupied volume consisting of the sand grains themselves. This figure, in turn, means a coefficient of volumetric expansion of $\frac{100}{63.2}$ or 1.58. This is the limiting value of the coefficient as indicated from the experiments.

It can hardly be expected, however, that the sand will subside to its limit without any arching of the grains taking place. When this arching begins to occur, the expansion characteristic begins to curve away from the straight line, and the final volume occupied depends on the degree of arching that has taken place.

Effect of sand grain shape and gravity. In the first paragraph of this paper the physical characteristics of the sand grains upon which the wash expansion depends were stated as size, shape, and specific gravity. The experiments described were for the purpose of investigating the effect of size only.

It is reasonable that two sands of the same size and grading, but differing in the shape of their grains, would vary in expansion with the same rate of wash.

It is also certain that the specific gravity of the sand has a marked effect upon expansion. Any marked deviation from a specific gravity of 2.65, which is that of clean silica sand, will affect its washing characteristics accordingly. Of two spherical sand grains having the same diameter, the one having the lower specific gravity is lighter, while the forces tending to lift both grains remain the same. The lighter particle, therefore, reaches its equilibrium at a higher plane. The present experiments do not take such a difference into account.

Accumulation of coating in filter sand may result in a marked reduction in its specific gravity. Such a coating, amounting to

perhaps ten per cent by weight of the sand, has usually a specific gravity (dry) only a little lower than that of silica sand and does not therefore, of itself, effect a marked reduction in the weight per unit volume of the grain. However, the coating does absorb and hold a very large amount of water, and this absorbed water accounts for the very much lower specific gravity shown by such a jelly coated sand.

For this reason sand expansion measurements made on a so-called "ripened" filter bed may be very misleading, unless the lower gravity of such a sand be taken into account. Further quantitative data are necessary for any exact evaluation of the effect of either sand grain shape or alterations in specific gravity as effecting sand washing characteristics.

Summary and conclusions

The action of wash water flow upon a bed of filter sand is such as to expand the bed an amount which is proportional to the original sand thickness.

The expansion is independent of the amount of free-board or lift above the sand.

It depends for its value upon the rate of flow of the wash water, the temperature of the water, and upon the size of the sand grains; as the rate of wash increases, the expansion increases; as the temperature and size of sand grains increase, the expansion decreases. Within the limits of accuracy of determining the values of the several factors involved the rate of wash necessary to bring about the desired degree of expansion can be represented by the formula.

$$r = [1.04 + 0.01 (t - 32)] (s - 0.17) e + \frac{5.9}{1 - (s - 0.17)} + 0.24s (t - 32) - 7.4$$

where

r = rate of application of wash water, expressed in inches per minute.

e = resultant expansion, expressed as per cent of original depth.

t = temperature of water in degrees Fahrenheit.

s = diameter of grain such that 30 per cent of the sample, by weight, is finer.

DISCUSSION

FRANK W. HERRING:³ The condition of stable equilibrium of the sand while in suspension can be studied from the standpoint of mechanics.

Consider first a single grain of sand immersed in a body of still water. This grain, of course, would be subjected to an upward force which is the resultant of the forces of hydrostatic pressure upon it, and which opposes the force of gravity on the particle. This upward force, or "loss of weight," is equal to the weight of the water displaced by the particle (Archimedes' Principle) and thus depends upon the volume of the sand grain and the specific gravity of the water. With the materials being considered, sand and water, this upward force is always less than the force of gravity upon the grain, so that an unbalanced force, known as the "effective weight" is in action, tending to carry the grain vertically downwards. Only in such a case where the weight of the displaced water is equal to the weight of the particle, would this unbalanced force be absent, as, for example, when the particle itself has a specific gravity equal to or less than that of the liquid.

It is a fundamental principle of mechanics that an unbalanced force acting upon a body causes an acceleration. If, therefore, this sand grain is allowed to fall freely through the water, the velocity of falling will tend to increase. But an additional force comes into action as soon as the particle has any velocity at all—the force of resistance or friction of the water. And this force is not a constant one, but increases as the velocity becomes greater. This force acting in opposition to the motion of the grain must now be subtracted from the effective weight to find the accelerating force. We have, in effect, therefore, an accelerating force which is constantly decreasing as the velocity becomes greater. It follows, of course, that there comes a time when the force of resistance equals the effective weight and the accelerating force becomes zero. Thus we have a condition of dynamic equilibrium, no further acceleration, and a constant velocity of the particle. This velocity of equilibrium, or terminal velocity, or hydraulic value is a very important characteristic of such a system as has been described and is a phenomenon not only of a sand in water, but also of settling material in a sedimentation basin, rain drops or snow flakes falling through air, electrically charged particles in a magnetic field, etc.

The value of the terminal velocity depends upon the size of the particle, its specific gravity, and the specific gravity and viscosity of the water. And with different size particles of the same material, the larger particles have a greater terminal velocity. This is evident from the fact that the effective weight varies as the volume of the

particle, of the third power of its diameter, while the resisting force is a surface phenomenon and varies only as the second power of the diameter. For example, a hollow sphere, under the same velocity conditions would encounter just the same resistance as a solid sphere of the same diameter.

The important point to consider in this case, however, is that terminal velocity really refers to relative velocity between sand grain and water. If the body of water itself is given an upward velocity equal to the terminal velocity of the grain, the grain will not appear to be in motion. Any slight difference between the water velocity and the grain velocity, however, will result in a correspondingly slight velocity of the grain in the direction of the greater value.

As an illustration, consider a tapering glass tube, the small end down, with water traveling upward through it, and overflowing at the top. If a small sphere is dropped into the top of the tube, the water velocity at that point is not enough to support the sphere, and it will travel down until a section is found where the velocity is such that the forces of viscous resistance just balance the effective weight of the sphere. At any point below this level the sphere would be carried upward; at any point above, it would fall. Hence, there exists a condition of stable equilibrium at that point for the sphere.

But a bed of filter sand consists certainly of more than one grain, and our analysis must consider the modifying action of the neighboring particles. Of course, the space available for passage of water is only the spaces between the grains, or voids, and the larger this void volume is, the smaller will be the resulting water velocity.

Consider a group of four spheres, grouped in cannon-ball fashion, with water travelling upward through the group, and arranged in some fashion that all the water must go through the triangular space formed between the bottom three spheres. Let the rate of application of this water be so great that in passing through this space, the velocity attained is sufficient to lift the top sphere. As this sphere on top is lifted, the space available for water passage becomes larger, and the velocity correspondingly decreases. The top ball, thus reaches a position of equilibrium where the space available beneath it for water passage is just sufficient to cause a velocity that will support the ball. This mental picture can be enlarged to include two layers of spheres, indefinite in extent, and it follows that each one in the top layer will copy the action of the top sphere in the group of four. When equilibrium has been established, the entire top layer

will have been lifted a definite distance above its position of rest, and this elementary bed will be expanded.

ROBERTS HULBERT:² In addition to the work described in the preceding pages, studies were made of the behavior during washing of several samples of filter material in use outside of Detroit. A brief summary of the results obtained is given below.

I. Sand from Cincinnati, Ohio. Two samples were received: No. 1 being the old, coated sand in use 22 years; and No. 2 a sample consisting of a mixture of the old sand and the new, taken from a re-sanded filter in service three weeks.

(a) Sieve analysis; (b) Coating and Specific Gravity determinations; (c) Analysis of the coating substance and (d) wash water velocity—sand expansion measurements were carried out on these samples. The table below gives the results obtained from the laboratory work under (a) and (b):

	FILTER SAND FROM CINCINNATI, OHIO	
	Old sand	New sand
*Per cent of coating substance.....	94.5	16.1
Specific gravity of coating substance.....	2.56	2.56
Specific gravity of coated sand.....	2.62	2.645
Specific gravity of cleaned sand.....	2.65	2.65
Effective size, as received, mm.....	0.58	0.43
Effective size, after cleaning, mm.....	0.43	0.39
30 per cent size, as received, mm.....	0.66	0.54
30 per cent size after cleaning, mm.....	0.51	0.47
Uniformity coefficient as received.....	1.28	1.58
Uniformity coefficient after cleaning.....	1.49	1.51

* Referred to clean, dry sand. For example, 100 grams of original clean sand has accumulated 94.5 grams of coating.

It will be observed from this table that the accumulation of coating on the old sand has increased its size to a remarkable degree. Re-sanding of the filters, by the addition of new sand apparently slightly smaller than that with which the filters were originally filled, has resulted in making the size of the new sand mixture the same as that of the original sand. (Effective size in each case in 0.43 mm.)

Expansions of both sands at different wash water velocities were determined experimentally, the results being shown graphically by

curves Nos. 1 and 2, figure 13. Theoretical expansion curves are also shown, as calculated for each sample by the formula, which assumes a specific gravity of 2.65, that of clean sand. Since the gravity of the old coated sand was a little less than this, viz. 2.62, the difference may account for the fact that the theoretical curve for this sand

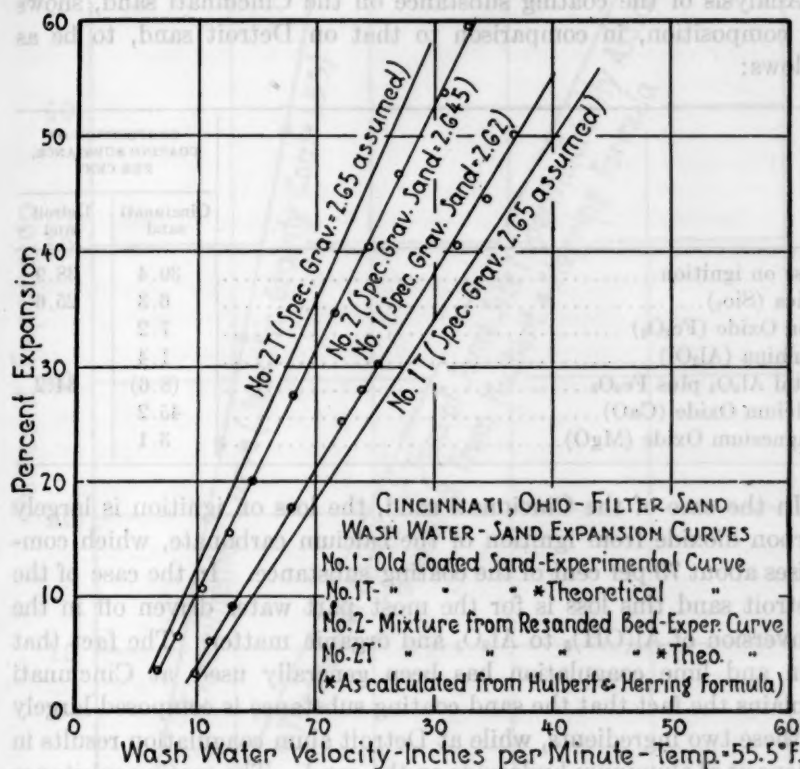


FIG. 13. CINCINNATI, OHIO—FILTER SAND. WASH WATER—SAND EXPANSION CURVES

(No. 1T) is a little below the experimental curve (No. 1). Both theoretical curves (Nos. 1T and 2T) are as close to the actual or experimental curves (Nos. 1 and 2) as might reasonably be expected.

The reason that Curve No. 1, figure 13, (old sand) shows a lower sand expansion for the same wash rate than does Curve No. 2 (new sand) is, in this case, almost wholly because of the increase in grain size of the old sand due to accumulated coating, and not because of

any marked decrease in specific gravity resulting from this. As it happens, in this case, the coating substance has a specific gravity of 2.56 or only slightly less than 2.65, that of sand. Hence, in a dry state, even the very large amount of coating substance on it (viz. 94.5 per cent) will only slightly affect the expansion of this sand.

Analysis of the coating substance on the Cincinnati sand, shows its composition, in comparison to that on Detroit sand, to be as follows:

	COMPOSITION OF COATING SUBSTANCE, PER CENT	
	Cincinnati sand	Detroit sand
Loss on ignition.....	39.4	38.9
Silica (SiO_2).....	6.3	25.6
Iron Oxide (Fe_2O_3).....	7.2	
Alumina (Al_2O_3).....	1.4	
Total Al_2O_3 plus Fe_2O_3	(8.6)	34.2
Calcium Oxide (CaO).....	45.2	
Magnesium Oxide (MgO).....	3.1	

In the case of the Cincinnati sand, the loss on ignition is largely carbon dioxide from ignition of the calcium carbonate, which comprises about 73 per cent of the coating substance. In the case of the Detroit sand this loss is for the most part water driven off in the conversion of $\text{Al}(\text{OH})_3$ to Al_2O_3 and organic matter. The fact that iron and lime coagulation has been generally used at Cincinnati explains the fact that the sand coating substance is composed largely of these two ingredients, while at Detroit alum coagulation results in a deposit of aluminum hydroxide on the sand. The coating substance on the Cincinnati sand is heavier than that on the Detroit sand in the ratio of 1.3 to 1.0.

II. Filter coal from Denver, Col. (a) Approximate analysis of the sample shows its composition to be

	per cent
Volatile combustible matter and fixed carbon.....	88.8
Acid-insoluble ash, largely silica.....	9.0
Acid-soluble ash (by difference).....	2.2

These determinations merely establish the fact that the sample is a pulverized coal.

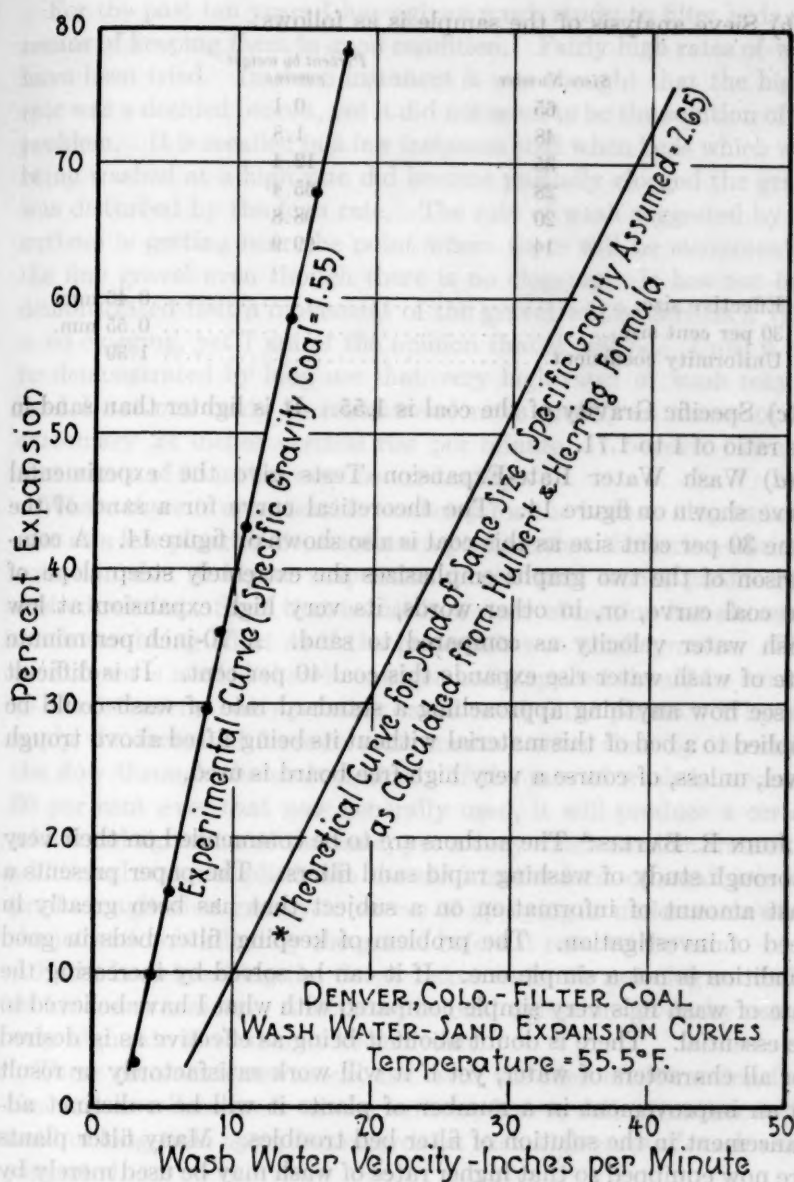


FIG. 14. DENVER, COLO.—FILTER COAL. WASH WATER—SAND EXPANSION CURVES

(b) Sieve analysis of the sample is as follows:

Sieve Number	Percent by weight passing
65	0.1
48	1.8
35	12.4
28	65.4
20	98.8
14	99.9

Effective size.....	0.46 mm.
30 per cent size.....	0.55 mm.
Uniformity coefficient.....	1.39

(c) Specific Gravity of the coal is 1.55. It is lighter than sand in the ratio of 1 to 1.71.

(d) Wash Water Rate-Expansion Tests give the experimental curve shown on figure 14. The theoretical curve for a sand of the same 30 per cent size as this coal is also shown on figure 14. A comparison of the two graphs emphasizes the extremely steep slope of the coal curve, or, in other words, its very high expansion at low wash water velocity as compared to sand. A 10-inch per minute rate of wash water rise expands this coal 40 per cent. It is difficult to see how anything approaching a standard rate of wash could be applied to a bed of this material without its being lifted above trough level, unless, of course a very high free board is used.

JOHN R. BAYLIS:⁴ The authors are to be commended on their very thorough study of washing rapid sand filters. The paper presents a vast amount of information on a subject that has been greatly in need of investigation. The problem of keeping filter beds in good condition is not a simple one. If it can be solved by increasing the rate of wash it is very simple compared with what I have believed to be essential. There is doubt about it being as effective as is desired for all characters of water, yet if it will work satisfactorily or result in an improvement in a number of plants it will be a distinct advancement in the solution of filter bed troubles. Many filter plants are now equipped so that higher rates of wash may be used merely by opening the washwater valves more, and it is hoped that the higher rate will be given a thorough trial in a few plants.

⁴ Chicago, Ill.

For the past ten years I have given much study to filter beds and means of keeping them in good condition. Fairly high rates of wash have been tried. In some instances it was thought that the higher rate was a decided benefit, yet it did not seem to be the solution of the problem. It is recalled in a few instances that when beds which were being washed at a high rate did become partially clogged the gravel was disturbed by the high rate. The rate of wash suggested by the authors is getting near the point where there will be movement of the fine gravel even though there is no clogging. It has not been demonstrated that a movement of the gravel will be serious if there is no clogging, yet I am of the opinion that it will be. Until it can be demonstrated by long use that very high rates of wash may be used I am not ready to recommend rates greatly in excess of the customary 24 inches vertical rise per minute. I believe, however, that a rate of 30 inches may be used safely.

Where there is considerable tendency for the beds to clog as is the case at a few plants it does not seem possible that the little additional agitation due to higher suspension of the sand would produce the desired results. Sand that is just in a state of motion has almost as much scrubbing effect as if the backwash was much greater. That more force is needed than is now generally applied should be evident to almost every one operating rapid sand filter plants. Why not apply the increased force in some manner other than by increasing the flow through the underdrains? If the rate of wash is increased 50 per cent over that now generally used, it will produce a certain additional agitation of the sand, yet a very much smaller amount of additional water applied into the sand in the form of small jets will produce agitation greatly in excess of applying it underneath where the jet action is killed by the gravel before it reaches the sand.

Filter beds handling the Great Lakes water do not clog so readily as for many waters. A little additional agitation given by using a very high rate of wash may be sufficient.

These comments are made, not with the idea of detracting from the very excellent work of the authors, but to call attention to the need of long-time operating records on such high rates of wash as are suggested.

WYNKOOP KIERSTED.⁵ The authors of the paper under discussion have presented a most interesting and enlightening description of a

⁵ Kansas City, Kans.

series of experiments of washing rapid filters; in fact, these studies and experiments throw more light upon what constitutes proper operation and design of rapid filters than any preceding tests and discussions with which the writer is familiar. The authors are to be congratulated particularly on having confined their discussion to one channel and on having selected, among several others, that channel so closely and fundamentally associated with the proper design as well as with the successful operation of the rapid filter. This fact renders the results of the authors' studies in this particular and the findings based upon these results all the more far reaching, acceptable and conclusive.

It is conceded that the sand placed in a rapid filter should be clean and the authors' studies prove that thereafter the sand should always be kept clean and free of adhering matter. It is also well known that a coagulum is necessary to render a high rate of filtration feasible. These considerations seem to confirm the view often expressed by the writer that rapid filtration is purely a mechanical process and is and should be in no wise associated with the vital process attributable to the slow sand filter. In other words the studies seem to dispel completely the idea of a "ripening" period for the sand of rapid filters before becoming efficient. To the writer's mind any attempt to combine a purely mechanical with a biological process in the working of a rapid filter is sure to end in failure in some respect. This statement the writer believes to be correct whether the rapid filter is used for filtering turbid river water or lake water containing more or less microscopic organisms. Were this distinction to be accepted less complication should arise in the mind of a designer of rapid filters for the filtration of water from either source.

The settling basin is the best place to prepare the water from any source for filtration. Here there is a wide range for the exercise of the ingenuity and good judgment of the operator. More effort concentrated upon the design and manipulation of the settling basin and in the application of the coagulants and the sterilizer therein, is the surest way to end trouble with the rapid filter provided the filter itself is kept clean in the manner suggested by the authors. Then no difficulty should be experienced in producing a sparkling and practically sterile effluent from rapid filters.

The commonly accepted high-velocity wash as the most economical

means of cleaning filter sand has long been an indefinite term. A vertical rise of 2 to 2½ feet has been regarded as about the upper limit. However the authors' experiments show that the high velocity wash, so measured, really means nothing definite since sand expansion, the direct result of high velocity wash and the intensity of sand attrition depends upon the depth of the sand, density or temperature of the wash water, size and character of the sand grains as well as upon the velocity of wash water flow. This means that the rate of wash for any established filter plant, particularly one deriving water supply from surface sources, should change according to seasonal changes of temperature in order to insure both thorough sand cleaning and economical operation. It is because of this seasonal variation of the rate of wash that the vertical rise method of measurement becomes unreliable as a guide. The suggested measurement of sand expansion is certainly a much more definite and safer guide. The designers of filter plants can readily make the benefits of it useful to the operator by installing a gage for measuring and recording sand expansion.

The formula suggested by the authors for measuring the vertical rise is certainly of great advantage to the designer and skillful operator, but to the ordinary filter operator in the smaller cities and towns it becomes of doubtful utility since he must rely upon some visual index for a guide. The authors have pointed out several methods by which the sand expansion can be measured and doubtless other methods will present themselves to the designers and operators of rapid filters. The sand expansion method as a guide to the proper washing rate of flow so strongly appeals to the mind of the writer that he desires to take the earliest opportunity of applying it to a filter plant now in process of construction.

The authors have shown that the thorough cleaning of the filter sand at every washing does not reduce the bacterial efficiency of the filter. Not only does this proof dispel all ideas that there is such a thing as a "ripened" or "seasoned" rapid filter, but it is also one of the strongest proofs of the assertion hereinbefore made by the writer that rapid filtration should be considered as purely a straining process, dependent for its efficiency upon the coagulum that forms upon the sand and around the sand grains in the upper portion of the sand bed. There certainly can be no use of preserving any part of this coagulum after its filtration resisting power becomes too great for

economical filter operation. It is extremely foul and loaded with bacteria and should be eliminated as thoroughly as possible at each washing. In fact, the authors show a considerable saving in initial filter head in doing so. In this connection a question arises in the writer's mind as to the depth of penetration in the sand bed of this coagulum. Possibly the authors can throw some light upon this question as it would seem to be pertinent to a consideration of the necessary depth of sand bed as well as to that of sand washing. If the ordinary depth of 30 inches of sand can be safely reduced it will insure a saving in structural costs and possibly a saving in the necessary amount of wash water.

H. E. JORDAN:⁶ In making a study of this valuable contribution to the water purification literature, one's first reaction is to congratulate the citizens of Detroit for their good fortune in having the design of the new plant so carefully studied. This work, along with other studies which have been made preparatory to the construction of the plant, will insure the taxpayers of Detroit a maximum return for the investment they make.

Experimental data and conclusions of the authors may be condensed into four brief statements:

- (a) Instead of the customary wash water rise of 24 inches or less, the data indicate that an upward velocity as high as 43 inches may be successfully and continually employed.
- (b) Under this operating condition the wash water consumption amounts to about 4 percent of the total filtered output.
- (c) Filters so washed do not build up the sand grain incrustation nor do they suffer from the characteristic ills that may be grouped under the general head of surface shrinkage.
- (d) Finally, the bacterial efficiency of units so treated is higher than those washed at the more conventional velocities.

That the bacterial efficiency of units having the cleaner sand is greater than that of the conventional units, must be due to one of two facts—either the conventionally cleaned unit is at all times subject to a certain degree of surface shrinkage that permits short circuiting of the water through large openings between the sand grains or whatever surface efficiency the ordinary unit may give is partly offset by a later contribution from the sub-surface bacterial growths.

⁶ Indianapolis, Ind.

Experience with bacterial reproduction in other parts of a water works system and acquaintance with the rapidity with which these growths are sometimes set up, would indicate that the reproduction phase of the unfavorable bacterial counts in the conventionally washed unit is a more likely explanation. On the other hand, it is worth emphasizing, as the authors have done in part, that between the time that a new filter plant is put into operation and the time its operating conditions have reached a satisfactory *norm*, there is a conditioning of the sand layer which most of us interpret as the growth of an organic film upon the sand grains. In the absence of this organic film, bacterial efficiency is very low and the production per square foot of surface below normal.

It will be interesting to know what the authors' opinion is of the method of measuring a desirable and normal grain film. It is clear from their experiments in passing on from the desirable condition, sand grains may add to this a film material, which probably is of a different character in which putrefactive or septic type organisms are present, until the surface shrinkage phenomena is evident. The plant operator who has these studies available for his information will undoubtedly attempt to improve the operating conditions in properties under his control. In doing that, if his wash water consumption is lower than the 4 percent mentioned by the authors, he may attempt to evaluate the return that he is likely to get for the additional expenditure of wash water. So long as the bacterial quality of the final product can be maintained by methods previously used and which are not likely to be eliminated by the changed wash water conditions, he may question the utility of the very high velocity wash, even though it does improve the appearance of the filter units. This is not to be construed as minimizing the importance of clean filter sand or as excusing any operator for the extreme conditions of surface shrinkage when a reasonable method is known of eliminating them.

One plant in the Middle West, operating with an expenditure of 1.1 percent wash water for the routine filter washing, makes a practice of washing rapid sand units about three times a year, with certain portions of the Nichols Sand Separator units. The annual charge for this operation is \$1.50 per cubic yard for labor and supervision and 52½ cents per cubic yard for power to operate the high pressure wash water pumps. This method of washing uses approximately 18,000 gallons raw water per year per cubic yard of sand in the filter unit, delivered to the ejector on 110 pounds pressure. With the low

normal wash water use, this seasonal handling of the entire sand layer with the separator does not prevent the growth of small mud balls and does not prevent certain late summer tendencies toward surface shrinkage. The overall efficiency of the plant, from a bacteriological standpoint, is satisfactory and the operation of the filter units, measured in terms of the turbidity of the filtered water, is satisfactory.

With the information available from the Detroit experiments, there is no question that the operators of the plant above referred to will study their present methods more carefully, to the end that increased efficiency be attained if the cost of modified method is not greater than the present one.

E. SHERMAN CHASE:⁷ The authors of these "Studies" deserve the gratitude of the designers of water filters for the excellent presentation of the data obtained in the interesting and instructive series of experiments upon the washing of filter sands.

A great deal of modern practice in the design of water filters is based upon precedent. Among the various features connected with filter design which follow more or less standard practice are depth of sand and gravel layers, specifications for sand and gravel, rate of filtration, and rate of wash. Whether accepted practice is the best practice under all conditions may well be questioned.

The authors appear to have demonstrated that under Detroit conditions a much more rapid rate of wash than ordinarily used is desirable. Studies at Baltimore⁸ have also indicated that a higher rate of wash than the usual 2 feet per minute vertical rise is a material aid in securing clean beds. The new filters at Greenwich, Connecticut, were designed for a wash rate of 24 inches vertical rise per minute, but experience has shown that better results are obtained with a 29-inch rate.

It should not be overlooked that high rates of wash and other methods for keeping filter sand clean are not substitutes for adequate preliminary treatment. Proper coagulation and sedimentation will do much towards preventing filter troubles.

The horizontal flow of water from the filter walls as observed by the authors has been noted elsewhere.⁹ This horizontal pressure in

⁷ Boston, Mass.

⁸ Engineering News-Record, May 23, 1929, p. 841.

⁹ Engineering News-Record, September 2, 1920, p. 441.

conjunction with coated and compressible filter sand is a reasonable explanation of the shrinkage of sand away from the side wall.

The suggestion of the authors that a sand expansion index for the filter wash be used in place of the usual rate of vertical rise is worthy of consideration. The formula which the authors have developed appears logical. The question arises, however, as to the accuracy of the constants in this formula for sands outside the usual ranges of effective size and uniformity coefficient. At Greenwich, for example, two of the units are provided with sand having a uniformity coefficient two or three times as large as that usually considered satisfactory. Incidentally it may be stated that these units have functioned fully as well as the other units having sand of conventional characteristics.

Whether the results of the Detroit experiments may be taken as applicable elsewhere cannot of course be determined at this time. It is probably true, however, that the experience of others also points the way towards the adoption of higher rates of wash. The writer has heard recently praise of mechanical rakes for use during filter washing. This praise of mechanical rakes was heard at a paper mill where three sets of filters are in use, one set equipped with rakes, another with air and water wash, and the third with high velocity water wash. It may well be that at the mill referred to the high velocity suggested by Messrs. Hulbert and Herring would be as effective in keeping the sand clean as the mechanical rakes.

Although at times it seems as though the art of water treatment had become standardized, there still remain many points relating to usual practice which require demonstration by experimental research such as that carried out by Messrs. Hulbert and Herring.

W. W. DE BERARD:¹⁰ When I finished reading and abstracting this paper I felt like writing headlines with "Startling," and "Consternation" in them. If what has been found will apply all over the country, it will be an amazing thing.

When one thinks of a 43-inch vertical rise and realizes what it means to get that much water through an underdrain system, get it pumped or brought to the underdrain system under a pressure head from a stand-pipe and in the capacities required he finds that he is up against larger sizes than any yet provided in any filters in the country.

¹⁰ Chicago, Ill.

That is the reason that the results of the investigation seemed so startling to me. It overthrows practically all designs up to date so far as providing sufficient wash water capacity is concerned. These men are certainly to be congratulated upon their bravery in coming out with such unusual and epoch-making results.

It occurs to me that one diagram shown by Mr. Herring may give the designers and operators a little bit of consolation. That is the one showing the smaller specific gravity of coal, which is a medium other than sand that can be used for filtration material. If coal can be washed at a very much lower rate and give the higher expansion, perhaps we can get along with existing plants until such time as we can find money to design for these larger capacities.

C. P. HOOVER:¹¹ It has already been suggested in the discussion that the preliminary treatment of water may have something or a lot to do with the successful operation of a rapid sand filter.

Filter sand troubles from shrinkage, cracking, mud balls and incrustation of sand grains is perhaps more pronounced in a water softening plant than in a straight mechanical filter plant. Especially was this true before the days of recarbonation of softened water.

What is the cause of all this trouble? The authors have demonstrated that it can be avoided in Detroit and Mr. Lawrence has reported that it was overcome in Cleveland by washing the filters at a rate to obtain 50 percent or more expansion of the sand. This, it has been shown, prevents the accumulation of organic and inorganic matter upon the sand and if the sand is kept clean, no operating troubles occur. The question then is, why does this objectionable material adhere to the sand grains?

My experience at the Columbus water softening plant convinces me that water softening reactions are induced by contact. We know that the alkalinity of lime softened clear settled water will be reduced as much as 30 to 40 p.p.m. by passing through sand filters, and that sand filtering such water becomes badly coated. We also know that softened water may contain a great deal of calcium carbonate in suspension, but if the reactions are completed by recarbonation the suspended matter will be successfully filtered out by the sand. Strange as it may seem, however, the sand will not become coated with an adherent coating.

¹¹ Columbus, Ohio.

The authors report that the results of analyses of deposit taken from the sand at Detroit show that it is a mixture of alumina and clay. This would seem to suggest that it might be possible that the sand becomes coated because the alum flocculation had not been completed before the coagulated water reached the filter. Flocculation or reaction may have proceeded after the water came in contact with the sand and from the results of our observations in filtering lime softened water, we believe that when precipitation or flocculation is induced by coming in contact with sand, the precipitate or flos adheres to the sand.

A great deal of filter sand trouble might be avoided by more adequate treatment of the water ahead of the filters.

W. C. HIRN:¹² I have talked with different men about this paper and it is the general opinion that the job has been so thoroughly done that there is not much left to discuss. The results of the experiments described in the paper this morning on the cleaning of sand are so good that I would like to see those experiments continued a little farther in some way with some of the filter plants in the Upper Peninsula, where they have very highly colored water, to see if the caustic soda treatment there would be as successful as it is where the water of the nature treated in Detroit is used. The plants in the Upper Peninsula have a great deal of trouble with coating of sand.

Mr. Hoover brought up one important thing to consider, and that is, why sand coating accumulates. This is a problem on which some chemist can do extremely valuable work.

In the earlier stages of the experiments at the Detroit Filter plant, I was there one day and was talking to the men who were doing the experiments. It was extremely interesting to me to see the first thing they discovered, after a long series of experiments previous to their taking hold of the work. Experiments had been carried on with no definite control. When they really cleaned up the sand in one filter bed and got one filter bed under control the remarkable results described here today were obtained.

Another thing I would like to see done is to find out, in designing filter plants whether we cannot save a lot of money in filter sand and gravel. The amount of gravel and sand put into beds now is really something worth considering. If we can get clean sand and reduce

¹² Detroit, Mich.

the depth of gravel and sand safely and use a high rate of wash, it will be worth while.

G. GALE DIXON:¹³ It is entirely probable, as suggested by some of the discussions read here today, that the use of the high velocity wash in just the manner outlined in this paper and evidently proper for Detroit conditions, will not prove a panacea for filter sand troubles in all parts of the country. There is no reason to expect that it would, in view of the wide range of conditions in quality of raw water and in prevalence of algae growths, and the differences in preliminary treatment employed.

Regardless of that question, however, there is no doubt that the several papers presented today form the most important contribution on the subject of filter washing that has been given to the profession for fifteen years. The several fundamental principles are clearly set forth, thoroughly documented, and are universally applicable.

Some one has said that any important invention or scientific discovery is perfectly obvious—after it has been demonstrated; and this is as true in the present case as it was in the original invention of the wheel. It is interesting to reflect upon this obvious nature of the several fundamental principles which lie behind the immensely valuable experimental data which have been put before us today:

(1) It is perfectly clear that there must be a minimum expansion of the sand bed in order to give room for the physical process of washing of the grains; and that there must likewise be a maximum degree of expansion beyond which there is no point in going.

(2) We are all familiar with the violent change in the viscosity of water from what might be crudely termed the 100 percent condition in ice to a practical zero in steam. In America small attention in general has as yet been given to the relatively minor changes in viscosity within the narrow range of temperature of water as handled in hydraulic works, although it is recognized that relative temperature and resulting viscosity cause important effect in the friction of water flowing through small pipes. In application to the washing of filters, obviously, increased viscosity means greater frictional resistance in passing through the sand; and increased frictional resistance must mean increased swelling of the bed in order to permit the water to pass through.

¹³ Youngstown, Ohio.

(3) Regarding the effect of the size of sand grain, those of us who have had to do with foundation work have many times observed that the upward flow of a relatively small quantity of water through fine sand will result in making it so "quick" that a man may be lost in it; while with a very much larger flow, a foundation in gravel will remain perfectly solid.

These thoughts crudely represent the fundamental hydraulics of this paper; and their applicability and importance in filter washing are perfectly obvious—after they have been shown to us.

You are doubtless familiar with the fact that Baylis is attempting to accomplish the same result in avoidance of sand bed troubles in his experimental plant at Chicago by different means. He agitates the surface of the sand bed by water jets from perforated pipes under about thirty pounds pressure for a period of two or three minutes before starting the upward wash. In the case of waters where the algae growths are more intensive than they are in Detroit, it is probable that something of this sort may be necessary in addition to a normal wash based on proper expansion of the sand bed.

There is one other thought which I want to offer to filter operators. It would be of great value to record and analyze the results of accurate observations of friction losses in the wash water piping systems of a number of plants; the piping systems are complicated and the accuracy of computed friction losses is uncertain; it would be interesting to know what effect temperature and viscosity of the water may have in this instance.

WM. GORE:¹⁴ I ascribe a high value to both of the papers dealing as they do with the important subject of cleaning filter sands. The subject is of equal importance to the filter operator and the filter designer. Mr. Hulbert has shown that the cause of filter bed cracking and consequent irregular operation is insufficient scouring of the sand and Mr. Herring has dealt with the various problems encountered when endeavouring to increase the scouring of the sand by greater rates of backwash.

Recently the officials of the capital City of Ottawa, Canada, like the City of Detroit, found it desirable to carry on filtration experiments as an aid to the design and operation of a purification plant. Many of the problems encountered were similar to those described

¹⁴ Toronto, Can.

by Mr. Hulbert, but many were quite different and it is interesting to note that different waters do give different results. It was found, however, that in order that two filters should work in parallel and give similar results the sand must be kept scoured clean. This could not be done with a 24-inch vertical rise backwash. Probing the bed during backwashing with a rod disclosed a certain sluggishness in the corners and along the sides of the filters. As it was inconvenient to increase the rate of backwash it was decided to scour the beds every two weeks with a fire hose. It was also found necessary to wash out biweekly every part of the system. The experiments at Ottawa lead us to increase the amount of backwashing at the boundary of a filter and to keep the length of boundary as short as may be convenient. In this way it is believed satisfactory washing of the sand will follow without high rates over the whole bed.

One remarkable fact disclosed by the experiments of Hulbert and Herring is the effect of temperature upon sand expansion during backwashing. In my own experience I have used manometers and pressure gauges to control backwashing and this no doubt will have masked to a great extent the remarkable effect of temperatures.

Some years ago I carried out a number of backwashing experiments in a glass sided filter. These experiments showed that after a permanent regime of washing had been established and the expansion for a given rate of backwash complete the sand bed divided up into horizontal zones or layers generally three in number with almost truly level planes in between. Between the planes there was a remarkable instability like a cauldron boiling which kept within its zone. There were great up-rushes here and there with corresponding down-rushes at some other points. Increasing the rate of backwash rapidly caused disturbances over the whole depth, breaking up the zones and giving shocks to the underdrains until the expansion corresponding with the increased rate had been established.

These experiments led me to the belief that backwashing is an exceedingly unstable process. In my judgment the backwash rates of 42 inches found in the experiments of Hulbert and Herring without causing undue expansion will need some modification when applied to actual filters which extend over large areas in which there are troughs. As a case in point the drifting sand filters at Toronto, each covering 1745 square feet with a depth of sand of 9 feet, a backwash rate of about 16 inches has been found not only sufficient but greater rates cause the sand to be thrown, although the free-board is 4 feet. The

drifting of the sand, however, is a sure preventative of dirty sand and its attendant evils.

MYRON G. MANSFIELD:¹⁵ This paper presents the results of one of the most comprehensive studies on filter washing that are available to assist the engineer in designing rapid sand filter plants and the operator in operating such plants. The authors make no pretense at stating that the findings have universal application, but there is no reason to believe that the data presented cannot be applied to any plant operating with a raw water from the Great Lakes or other source having similar characteristics.

Two of the more outstanding findings, namely, that ripening of rapid sand filters is not essential, and that filters can be washed thoroughly before being placed back in operation, are at variance with findings at other places, thus illustrating the caution with which these particular results should be used.

Sand coatings

Although the coating experienced on the sand grains at the Detroit Filter Plant is typical of most coatings causing difficulty in filter plant operation, each coating is more or less dependent upon the type of raw water treated and the methods used in coagulation. As in the case of the coatings on the inside of cast iron pipe systems, it is probable that the coatings on highly mineralized water would be much tougher and therefore much more difficult to remove than coatings experienced in less mineralized waters. The case of Cincinnati is one of a different type of coating, although this is due to the method of coagulation rather than the quality of raw water. It is probable that such a coating would not be remedied by the same procedure as at Detroit.

Methods of agitation

Two methods of agitation were tried out in Detroit and both found successful, namely, the use of a high rate of wash and the use of rakes. Inasmuch as agitation is the chief reason for efficiency in washing, it should be possible to obtain good results by other methods as well. In the history of rapid sand filters, numerous devices have been employed, such as mechanical rakes used in circular filters, the

¹⁵ Pittsburgh, Pa.

use of air in combination with water, increased rates of wash, and, more recently, the use of surface grids which bombard the sand grains with streams of water at high pressure, these streams being applied close to the sand surface.

At Detroit, it seems apparent that the high rate of wash is the logical solution. Filter plants treating a raw water of high turbidity and high mineral content may have more success with the old air wash or the newer surface grid system.

It is interesting to note that Cambridge, Massachusetts, has had success in eliminating mud balls by weekly rakings by hand. While this method is not popular with operators, the fact that it is only necessary once a week to prevent excessive mud ball formation should give it some standing for consideration in an existing plant.

Sand specifications

From a study of the paper, it would seem in the light of the results obtained that perhaps the 30 percent size of sand has as much, if not more, significance than the familiar 10 per cent or effective size of general usage. This brings up the question as to whether it is the "expansion coefficient" of the upper few inches of sand rather than of the entire bed which is the governing factor. If this were the case, the governing size of the filter sand would be the 30 percent size for the upper few inches rather than the 30 percent size of the entire bed which probably would correspond closely to the present effective size in general usage.

Removal of coating

The method of removing coating by the use of a lye solution should be generally welcomed by operators, although somewhat similar methods have been used in the past. It may be of interest to record that coatings of considerably greater percentages have been experienced in old filter plants. Some of these have been so high that it has not been thought feasible to remove the coating, inasmuch as the total volume of the reclaimed sand did not appear to be worth the expense and trouble.

This paper is an important addition to the literature on filter plant practice and it is hoped that the results of observations upon the operation of the full-size filters at Detroit will be published at a later date.

J. F. LABOON:¹⁶ I am very much impressed with the author's paper in connection with the treatment of Great Lakes waters. I accept all that he has given in this paper as characteristic of Great Lakes waters at this particular time. It is well to point out, however, that the conclusions are not entirely applicable to other waters where conditions vary.

There were several features of the paper which struck me with more or less force, such as the size of sand used in the experimental filter and the rate of wash water which has been found necessary to keep the filters clean. It has been conventional practice for engineers in this part of the country to use sand having a size of 0.35 to 0.45 mm. and a wash water rate of 24-inch rise. This is in severe contrast to the developments of the experimental filter as outlined in this paper. The rate of filtration used in the old Detroit Filtration Plant and in the experimental plant discussed in this paper is somewhat higher than the conventional rate of 125,000,000 gallons per day usually assumed for the average filtration plant. According to the tables given by the author a 0.40 mm. sand at 70°F., which may be assumed to be an average summer temperature of Great Lakes water, will require about 27.5 inches rise to obtain a 50 percent expansion. With waters of less temperature, this rate of wash water rise may be reduced for the same degree of expansion. Therefore, the conventional plant designed for a 24-inch rise should give satisfactory results, generally speaking.

This has been found to be true in practice, but in spite of such results, plants may be found which proved unsatisfactory in respect to the formation of mud balls and higher washes would probably cure this condition.

I have in mind a plant using Lake Erie water which operated satisfactorily with a 24-inch rise of wash water and approximately 0.40 mm. sand for more than fifteen years until suddenly it was discovered that mud balls were forming. A 36-inch rise of wash water was resorted to with the result that the filters have been operating with the greatest of satisfaction since, although all of the sand had to be removed and washed in order to remove the mud balls.

A question not touched upon in this paper and one with which every operator on the Great Lakes, especially on Lake Erie, has been confronted, is that of algae and that the periods of the year when algae

¹⁶ Pittsburgh, Pa.

troubles appear may be listed among the anxious moments, any such operator will not deny.

Two important factors which come to mind as having more or less bearing on the question of washing are coagulation and the distribution of the wash water through the strainer system. It seems to me that a poorly coagulated water would have a greater tendency to form mud balls than a well coagulated water and that the filter would be kept clean only with some difficulty, in spite of resort to higher rates of wash where coagulation is poor.

In our practice, we have adopted the false bottom type of distribution system which acts as a reservoir for even distribution and upward flow of the wash water. We believe that such designs have helped the washing of filters wherever they have been installed. The false bottom serves also as a place of entering in the filter in case of escaping sand or loosened strainers.

Furthermore, we have adopted as a policy the provision of a sand washing system consisting of a sand bin generally in the basement and an ejector with piping to and from the filters. The bin serves for storage of clean sand, should it be desired.

Again I wish to say that the paper adds materially to the literature of the society and is most welcome. Mr. Herring, I would like to ask at this time, did the 4 percent figure given in the paper refer to the total amount of wash water being used in the plant?

MR. HERRING:³ We washed the filters longer than necessary. For the purpose of smooth operation and for instruction to the operators of the filter plant, the duration of wash was set for five minutes regardless of the intensity of the wash. Observation showed that after two and a half minutes and at times three minutes the water rising off of the filter was clean. The time of wash could have been reduced to two and a half minutes, which would have reduced the required amount of wash water to 2 rather than 4 percent.

W. C. LAWRENCE:¹⁷ Speaking about wash water percentages, in Cleveland we have used about two and one-half percent wash water, on an average, for the last ten or twelve years.

Due to the fact that the United States Public Health Service have been trying to have filter plants produce a filtered effluent with a

¹⁷ Cleveland, Ohio.

coli index of one per 100 cc., we did considerable work on sedimentation. This work was over a period of approximately three years, where each month of the year I would operate one filter plant at possibly a short detention period and the other at a long detention period through the settling basins. The raw water delivered to both plants being fairly comparable, I was able to establish a certain detention period through the settling basins for each month of the year, whereby the water applied to the filters was as good as could be expected, showing a reduction in the B. coli indices of from 75 to 85 percent. Still with this good reduction through the settling basins, I was not able to produce a filtered effluent that would meet the required coli index of one per 100 cc. That led us to washing filters at a 50 percent sand expansion, the wash varying with the changes in water temperatures. This manner of washing has certainly cleaned up the filters.

Some of the members here are possibly alarmed at washing filters at a 39-inch rise, but do not realize that a sand of 0.40 mm. effective size washed at 24-inch rise, with the temperature of the water at 32° F., gives a 50 percent expansion, while a 24-inch rise with the temperature of water 73° F. would only give a 25 percent expansion. Therefore, to maintain the same washing effect of a 24-inch rise at 32° F. a 38- or 39-inch rise would have to be used at 75° F. In the winter months with a 24-inch rise, we are washing our filters three and a half minutes, while in the summer months, with this higher rise, we produce the same amount of work in one and a half minutes.

This year we have lengthened our filter runs 36 percent and saved 16 percent wash water over the previous year, by maintaining a 50 percent sand expansion.

ABEL WOLMAN¹⁸ AND SHEPPARD T. POWELL:¹⁸ Anyone reviewing the contribution by Messrs. Hulbert and Herring cannot fail to be impressed with the originality of experiment and the thoroughness of analysis in the experimental findings. That their findings should, therefore, prove more than usually interesting is not surprising. As in all partially unsolved problems of water supply treatment and particularly in the field of filter bed maintenance, any new experimental evidence is valuable because of the absence of extended and authoritative data under varying conditions of operation and of character of

¹⁸ Baltimore, Md.

water. The authors deserve considerable commendation for the detailed fashion in which they have carried out their tests and for the courage with which they present their findings. Obviously, it is impossible to comment in detail upon all of their experimental data, but there are a few general principles upon which we should like to make brief observation.

Since our own earlier contribution¹⁹ on the problem of sand bed shrinkage, we have been concerned, as have Hulbert and Herring, with the basic causes of sand bed shrinkage, mud ball formation and general deterioration of efficiency. In the contribution by Hulbert and Herring, as we read it, emphasis is placed primarily upon current defective practice in washing as a probable major cause of sand bed difficulties. With the conclusiveness of this finding, we are not yet prepared to agree. If it is presumed that current methods of washing are fundamentally the causes of difficulty, it is impossible to understand why filter beds in which no change whatever in washing is made, pass from bad operation to good, when only the medium in the bed is changed. Our experience during the last ten years has demonstrated clearly that substitutions of coarse clean sand (effective size 0.45 mm. plus) for fine sand (0.35 or less), have invariably resulted in the elimination of sand bed shrinkage, mud ball formation and inadequate filtration.

The concept of sand expansion quality is an exceedingly helpful one and its importance has been exemplified in some of our own experience. But even in this latter instance, we are not quite certain as yet as to whether inadequate wash or unsatisfactory sand was the primary cause of difficulty. For example, of 10 one million gallon per day units at a plant in Maryland, five are supplied with Cape May, N. J. sand and five with Hancock, Md. sand. Other than in the difference in the two sands, all ten beds are designed and constructed exactly alike, with the same provisions for amount of wash water and of free board. The effective size and uniformity coefficient of the two sands are about the same. The Hancock sand, however, is sharper and flatter in character than the Cape May sand, which is more rounded. These differences apparently are quite profound in their effects, for the Hancock beds were filled by using practically one car load less of sand than the Cape May beds, although both sands show approximately the same specific gravity when new.

¹⁹ Engineering News-Record, July, 1920.

In the Hancock beds, great numbers of mud balls and some shrinkage have resulted, while the Cape May sands have shown complete satisfaction in all directions. It was found, however, in examining the Hancock beds, that evidently the sand had retained from the freight cars considerable amounts of cinders and, in one bed, vast amounts of wheat grains, which served as the nuclei for mud ball formation. In this experience, do not the results point to the necessity of modification of sand medium rather than to the necessity of the expansion of amounts of wash water to be used, with resultant costly changes in wash water distribution system design and in overall depths of wash water troughs?

The authors' findings on the continued efficiency of clean sand as a filter medium are completely in accord with our own assumptions for many years in the past. The concept of the necessity of coated sand for bacterial efficiency apparently had its origin in the slow sand practice, where conditions of operation and methods of bacterial removal were not comparable with present day rapid sand practice.

Reverting to the important principle as to which is cause and which is effect in sand bed shrinking and mud ball formation, it would appear to us that only three postulates are possible. They are as follows:

(a) Given a good wash water procedure and a small sand (effective size 0.35 mm. or less), shrinkage and mud ball formation is likely to occur.

(b) Given a good wash (ordinarily 24 inches vertical rise per minute or better), and a large sand (0.45 mm. or more), no shrinkage or mud ball formation is likely to occur.

(c) Given an inadequate wash, with a large or small sand, shrinkage and mud ball formation will occur.

In our previous contributions to discussion on this subject, we have presupposed the existence of a standard wash as one of the concomitants of design. The variable to our minds is the sand medium. If carefully selected and of large size, we have found that no problems result.

Notwithstanding our differences of opinion, which are probably merely differences in methods of viewing the same results, the contribution by Hulbert and Herring is one of the most stimulating in recent years in this interesting field.

A STATE DIVISION OF HYDRAULICS AND MUNICIPAL WATER SUPPLIES¹

BY R. K. TIFFANY²

It is perhaps safe to say that no other state in the Union is more abundantly supplied with clear, pure water for municipal and other uses than the State of Washington. The supply is broadly distributed throughout the state and is generally easily accessible to gravity systems. This abundant water supply is likely to be a most important factor in our industrial and social development.

While the Constitution of the State of Washington sets out the state's ownership and control of water within its borders there was not until 1917 any state machinery for the exercise of such control. Water titles prior to that time were in a chaotic condition. Water rights were for the most part "squatter's rights," often without official record and with no practical means of determining the amounts that might be claimed or the relative priorities of conflicting rights.

The Act creating a Water Code which became effective on June 15, 1917, repealed seventy-five sections of water law scattered through three chapters of general law, and containing many conflicts and ambiguities, which were replaced by a condensed code of fifty sections. Some new sections have since been added, the chief purpose of which was to place the cost of administration upon those who are chiefly benefited. The responsibility for the administration of the Water Code rests with the State Department of Conservation and Development, the official directly in charge being designated Supervisor of Hydraulics.

The Division of Hydraulics in the Washington State Department of Conservation and Development has to do with the control, conservation and development of the State's public waters. The office and its duties were established by the Water Code, which became effective June 15, 1917. Under the Code the office was known

¹ Presented before the Pacific Northwest Section meeting, November 16, 1928.

² State Supervisor of Hydraulics, Olympia, Wash.

as "State Hydraulic Engineer," the title being changed by enactment of the administrative code in 1921 to "State Supervisor of Hydraulics."

STATE CONTROL

The first section of the Water Code above referred to sets out the basis and extent of the state's control over water and it may be worth while to read this section in full.

The power of the state to regulate and control the waters within the state shall be exercised as hereinafter in this act provided. Subject to existing rights all waters within the state belong to the public, and any right thereto, or to the use thereof, shall be hereafter acquired only by appropriation for a beneficial use and in the manner provided and not otherwise; and, as between appropriations, the first in time shall be the first in right. Nothing contained in this act shall be construed to lessen, enlarge or modify the existing rights of any riparian owner, or any existing right acquired by appropriation, or otherwise. They shall, however, be subject to condemnation as provided in section 4 hereof, and the amount and priority thereof may be determined by the procedure set out in sections 14 to 26 inclusive hereof.

RIGHT OF EMINENT DOMAIN

Section 4 of the Act provides:

The beneficial use of water is hereby declared to be a public use, and any person may exercise the right of eminent domain to acquire any property or rights now or hereafter existing when found necessary for the storage of water for, or the application of water to, any beneficial use, including the right to enlarge existing structures employed for the public purposes mentioned in this act and use the same in common with the former owner, and including the right and power to condemn an inferior use of water for a superior one.

This section of the statute presumably gives to cities, towns and water companies the right of eminent domain so far as may be necessary for their purposes. It is my understanding that the general tendency of court decisions is to recognize municipal use as one of the highest, if not the highest, of all uses for water.

POWERS AND DUTIES OF SUPERVISOR

Section 8 of the Water Code imposes upon the State Hydraulic Engineer the following duties and powers:

1. The supervision of public waters within the state and their appropriation, diversion and use, and of the various officers connected therewith.

2. In so far as may be necessary to assure safety to life or property, he shall inspect the construction of all dams, canals, ditches, irrigation systems, hydraulic power plants, and all other works, systems and plants pertaining to the use of water, and he may require such necessary changes in the construction or maintenance of said works, to be made from time to time, as will reasonably secure safety to life and property.

3. He shall regulate and control the diversion of water in accordance with the rights thereto.

4. He shall determine the discharge of streams and springs and other sources of water supply and the capacities of lakes and of reservoirs whose waters are being or may be utilized for beneficial purposes.

The engineer is further required to keep essential records, to provide a seal to be attached to all official documents, to render biennial reports to the Governor, to establish and promulgate rules governing the administration of the act, etc.

Of the duties and functions more particularly of interest to the members of this organization a few will be mentioned and briefly discussed.

INSPECTION OF DAMS

Besides the provision hereinabove quoted, the law requires that any person proposing to construct a dam for the storage of more than 10 acre-feet of water shall submit complete plans for approval or criticism by the State Supervisor of Hydraulics. Our statute makes no exceptions. Dams constructed by municipalities, or even by the Federal Government, are subject to state inspection as to safety. It must be admitted that until the St. Francis disaster the enforcement of this feature was rather perfunctory whenever the building agency had a staff of presumably competent engineers. Since that disaster a complete inspection of all dams in the state has been made and it is proposed to continue annual inspection of those dams which are so located as to constitute a menace to life or property. I am happy to say that all owners of dams have welcomed this additional check upon their safety and have coöperated most heartily in furnishing every possible assistance toward the inspection.

STREAM MEASUREMENTS

The Division of Hydraulics coöperates with the Water Resources Branch of the United States Geological Survey in maintaining gaging stations on as many of the important streams of the state as can be covered by the funds available. In addition, we have made miscellaneous measurements, generally during low water period of many

hundreds of streams, a large percentage of which will provide satisfactory municipal water supplies.

It would be desirable that more complete records be made of the streams most likely to be required for municipal use, but this cannot be done without additional funds. The revenues of the division, however, are steadily increasing and it is hoped that a considerable extension of the stream gaging program may be possible during the next and succeeding biennial periods.

There is no provision in the law for qualitative analysis of public waters, but this can be arranged for when necessary, through coöperation with the Division of Geology or if more convenient, with the chemistry departments of the State College and the State University.

WATER RIGHT ADJUDICATIONS

When there is a conflict of rights on a given stream or stream system, the State Supervisor of Hydraulics is authorized, on request of interested parties or on his own initiative, to bring action through the state courts to determine the extent and priority of various rights. In such an action all persons having rights upon the stream are made parties to the proceeding. A survey of the stream is made and a map and statement of physical facts is filed by the Supervisor in the court. After the usual preliminaries the matter is referred to the State Hydraulic Engineer, as referee, for the taking of testimony and the preparation of report based upon the testimony, in which is set out the quantity and priority of the various rights. This report is filed in the court. Opportunity is given for interested parties to except and after all exceptions are heard the court enters a decree, based upon the Referee's Report with modifications, if and as justified by the exceptions filed.

This plan of adjudication provides a final and economical adjudication of all rights along the stream, and thereafter the diversions from the stream are regulated by water masters appointed by the State Supervisor of Hydraulics in accordance with the decreed rights.

ACQUISITION OF NEW WATER RIGHTS

Rights to appropriate and divert water for beneficial use are acquired by a procedure under the statute which is briefly set out as follows:

An application is filed in the office of the Supervisor on blank forms provided for that purpose, in which is set out the name and post-office address of the applicant, the source of water supply, nature

of use and amount of water proposed to be used, time during which the water will be required each season, location and description of proposed diversion works and the time within which it is proposed to complete the construction and make application of water to proposed use.

Application is dated, filed and recorded. If defective, it is returned to the applicant but does not lose its priority on account of defect, provided that maps, drawings and other required data are filed in the office of the Supervisor within a reasonable time.

PUBLICATION OF NOTICE

On filing an application in proper form the supervisor furnishes to the applicant for publication notices setting out the amount, location, and purpose of the proposed appropriation, to be published in three consecutive weekly issues of a newspaper of general circulation published in the county seat of the county, in which the project is located. Thereafter it is the duty of the Supervisor, by himself or by qualified deputy, to examine the application, determine what water, if any, is available for appropriation and to what beneficial use it may be applied. The Supervisor is required to make written findings and file them and if he shall find there is water available for beneficial use and that the appropriation thereof "*will not impair existing rights or be detrimental to the public welfare*, he shall issue a permit, stating the amount of water to which applicant shall be entitled and the beneficial use or uses to which it may be applied." The statute further provides that "*where there is no unappropriated water in the proposed source of supply, or where the proposed use conflicts with existing rights or threatens to prove detrimental to the public interest, having due regard to the highest feasible development of the use of the waters belonging to the public, it shall be the duty of the State Hydraulic Engineer to reject such application and to refuse to issue the permit asked for.*"

The Attorney General has held that in case of conflicting applications priority of filing alone does not determine which shall receive the permit, but that the Supervisor has broad discretion to determine which applicant proposes the highest feasible use of the public waters and which proposed use will best serve the public interest. This, you will readily see, is of the utmost importance to cities, towns and water companies desiring to make use of public waters for municipal supply.

It has been the policy of the Department ever since the writer's

connection with it, to give preference to municipalities and to allow the greatest latitude in plans for future requirements of municipal water projects. In some cases applications for other uses which would conflict with future municipal needs have been rejected. Permits are issued to municipalities with the time for completion of construction as long as ten years or more so that those responsible for municipal water supply can plan long into the future and be sure of protection so far as state control of the water is concerned.

HYDROLOGY

The value of any stream depends upon the volume and regularity of its flow. One of the duties of the Division of Hydraulics is to measure the discharge of streams and capacity of lakes and other storage reservoirs which may be adaptable to beneficial use. In this connection we have the coöperation of the United States Geological Survey to secure records of flow of the more important streams. A bulletin giving a summary of all stream flow measurements in the state, beginning with the earliest made in 1879 and extending down to the close of the climatic year 1927, has been prepared and will be available as soon as it can be printed. This bulletin covers only the larger streams. On the smaller streams we have thus far been able to make only miscellaneous measurements. One or more measurements, generally at or near the low water period have been made on more than 2,000 streams and it is hoped that this work can be extended and a continuous record made on such streams as seem to be most adaptable for development for municipal, manufacturing, irrigation or other beneficial uses.

UNDERGROUND WATERS

While our statute provides that "Subject to existing rights all waters within the state belong to the public," there is no specific reference in the statute to underground waters and there has been no attempt made to exercise jurisdiction over them. The question of the desirability of state control over underground waters has been raised in connection with important artesian basins, where overdrilling threatens to exhaust the supply. Arizona and perhaps one or two other states have statutes giving the state jurisdiction over underground waters similar to our control of surface waters. It would appear very decidedly in the interest of conservation and economical use that our statute be extended so as to apply at least to artesian waters.

DEPRECIATION OF WATER WORKS FOR FEDERAL TAX RETURNS¹

By C. W. ORMEROD²

Sometime ago our organization made an investigation relative to the various methods used by subsidiary companies in connection with charging off adequate depreciation for Federal income tax purposes. We found that very few of the corporations had adopted the same method. It was manifest, therefore, that some uniform method should be devised whereby all companies would be handled alike for Federal income tax purposes. Some of the methods in use at date of acquisition by the Federal Water Service Corporation are as follows:

1. A fixed arbitrary amount
2. A composite rate applied to the total cost or book value of the property
3. A sum fixed by Public Service Commission (usually based upon reproduction costs new)
4. Various rates applied to the different classes of property
5. A percentage of gross revenue decreased by maintenance charges which method is usually provided for under bond indentures.

Regarding the methods for computing depreciation it was disclosed that some companies used the sinking fund method, others the straight line method and others the reducing balance method. We all recognize the fact that depreciation is based solely upon judgment and experience and that the rates are very often over or underestimated. We also realize that authorities on the subject of depreciation are not in agreement in many instances, which further complicates the problem.

From the methods outlined above it is manifest that considerable confusion exists in the water works industry relative to the handling of this problem. The purpose of bringing this matter before the Association at the present time is to formulate some procedure whereby the industry will act practically as a unit in handling this

¹ Presented before the Toronto Convention, June 26, 1929.

² The Federal Water Service Corporation, New York, N. Y.

problem for taxation. The matter has been brought forcibly to our attention through the recent action of the Treasury Department. We have information to the effect that the Treasury Department is now engaged in preparing a bulletin which will include rates of depreciation applicable to various classes of assets owned by representative taxpayers. The Treasury Department has stated in several of their statements issued to the newspapers on the subject that they will be glad to cooperate with associations of this character in order to formulate methods and procedure which will be satisfactory to taxpayers operating water works properties.

The Treasury Department is exceedingly anxious to cooperate in order that they may be guided by the experience of the taxpayers engaged in the various industries.

We are of the opinion that, if a uniform practice is adopted, savings will accrue to the members of the American Water Works Association totaling hundreds of thousands of dollars annually. From our own experience we know that considerable refunds of Federal income taxes can be obtained on prior years and substantial savings obtained in future years by establishing uniform rates for depreciation. The Treasury Department has entered into agreements with many individual companies in the water works field, but they are extremely anxious to establish a uniform practice covering the water utilities in the United States.

The factors to be considered in computing proper depreciation deductions are briefly:

1. The cost of the property
2. The useful life of the property after giving full consideration to the factor of obsolescence.

The Federal income tax laws provide that depreciation shall be computed for income tax purposes on the cost of property when it is purchased for cash. In connection with property acquired for securities or other property the fair market value of the property at the date of acquisition is used, which value should correspond to the fair market value of the securities or other property paid in exchange.

Where a corporation has appreciated the value of its fixed capital to agree with current reproduction costs, the Treasury Department does not allow depreciation on appreciation. This rule applies with equal force when properties are sold to new companies which are in the same affiliated group and controlled by the same interests.

The rules governing these transactions are described in the Revenue Acts under reorganization sections. The rule can be further explained by stating that the original cost or fair market value is not increased when properties are transferred in connection with tax free exchanges.

The question of establishing uniform rates and bases for deducting depreciation for Federal income tax purposes is not the only reason for bringing the matter to your attention at this time.

Public utility companies operating in various states of the United States are today confronted with increased taxation through the revision of present tax laws and the desire of the taxing authorities of the various states to find means for raising additional revenues. Recently the legislature of the State of California enacted a new tax law. The method adopted by the legislature of California in handling the problem of depreciation followed closely the Federal income tax requirements, with the exception that the California taxpayers could value their properties as of January 1, 1928, and apply the various rates of depreciation to the various classes of property based on that value.

At the present time bills are pending before the legislatures of Oregon and Washington similar to the one adopted by California. In addition to these, other states are gradually enacting income tax laws, as this method is one of the best for obtaining additional revenue. In states which tax utilities based on the value of property, it is obvious that proper depreciation is important. Inasmuch as the problem is one which has considerable bearing on the amount of tax paid to Federal, State and Local authorities, we feel that this question is of sufficient importance for the Association to consider.

The proper settlement of the question will save many thousands of dollars and eliminate a perplexing problem which always arises between the taxpayers and the Government when the taxpayers income tax returns are examined.

If this discussion appears to be of sufficient importance to the representatives present, it is suggested that a committee be formed at once for the purpose of starting this work.

It will be necessary to obtain the experience of various utilities operating in different states of the Union and hold conferences with the Treasury Officials at Washington. It is important to move rapidly as the Treasury Department expects to issue the bulletin under discussion by the first of the year.

A PRACTICAL METHOD OF CLEANING FILTER SAND

By EMIL K. VENTRE¹

The cleaning of sand presents a problem very much like the removal of scale or incrustants from a boiler or evaporator. It has been for many years standard practice in the sugar and like industries to clean heaters, evaporators and vacuum pans of scale by an acid and caustic soda treatment. A slight modification of the method enables the cleaning of sand and gravel to the extent that I believe by twice a year cleaning a filter may be operated indefinitely with only the addition of sand for that washed way.

In the use of alum treatment with a water high in organic matter a caustic soda treatment suffices. Where the pH of filter influent is neutrality or slightly below and where some of the trouble is due to the incorporation of unicellular algae and protozoa, similar use may be made thereof.

The strength of solution to be used can best be determined by individual experiment on sand in the laboratory and a check may be had on the tubes by submerging piece of same in solution for the time the solution is to be left in the filter.

I have used the following method with good results for cleaning, following alum treatment with sand showing high organic matter.

CAUSTIC SODA TREATMENT

1. The filter is thoroughly washed, then the water is drawn down to 4 inches over the sand, 500 pounds of 76 per cent caustic soda is distributed over the surface evenly with a spade. Area of filter is 20 by 30 feet.

2. The solution over the sand is stirred slightly with a broom to effect even distribution of solution and allowed to stand six hours to allow a thorough cleaning with full strength solution of the top and usually most dirty part of sand bed.

3. With a long pronged (6 to 8 inches) rake the sand is raked back

¹ Chemical Engineer and Bacteriologist, in charge of Municipal Water Purification, Monroe, La.

and forth to a depth of 12 to 14 inches depending on the depth of sand. Care is needed so as not to disturb the gravel. This is done every three hours for twelve to fifteen hours.

4. At the end of this time the filter to waste valve is opened and the water level is dropped to the surface of the sand and allowed to stand six hours more.

5. The filter is now washed until the wash shows an alkalinity of the wash water applied then put into service in the usual manner.

HYDROCHLORIC ACID WASH

Where iron and lime has been used as coagulant or where for any reason the incrustant on sand is mostly carbonate and not much organic matter. A wash on the principle of the soda wash using 10 per cent by volume of commercial hydrochloric acid will do the work.

Where a combination of conditions exist or in very dirty filters it is best to use a caustic wash as above and follow by an acid wash. In all cases a laboratory check or control should be carried out first to determine strength of solution and second to see that no harm is done the brass laterals. The acid wash seems to be the only thing that will help clogged laterals some without the expensive use of a punch.

It is my belief that many filters are dug up where cleaning would put them back in service for quite a time at a very low cost. By experiment in individual cases a filter with quite a bit of algae may have the cells dissolved and disintegrated by sufficient strength caustic solution. It is surprising the strength that may be used without any harmful results. However, when using the higher strength of caustic, always follow by an acid wash and vary the time of contact accordingly.

THE OHIO CONFERENCE ON WATER PURIFICATION¹

By F. H. WARING²

Early in 1916 the Ohio Department of Health initiated a campaign to secure better operation of the water purification plants in the state. Through these efforts many cities were induced to place responsible personnel in charge of the filtration plants. As a part of the routine work of the Department one of the assistant engineers visited each plant frequently and afterward conducted correspondence with the operator in charge regarding the details of the water treatment. It was observed that the chemist-in-charge of any one plant was very much interested in how the man in charge of some other plant was getting along and if the problems encountered were in any way similar. Often the same explanations and instructions were repeated in going from one plant to another. It therefore occurred to the writer, who at that time was in charge of this work, that a meeting at which several of these plant operators could be in attendance would be advantageous not only to them, but also to the Department.

Suggestions had also been made to the Department by several persons engaged in designing water treatment works that a conference of those interested in the subject should prove of value to all concerned. At a meeting in Cleveland in the spring of 1921 at the offices of J. T. Martin, commissioner of water, and J. W. Ellms, engineer of water purification, and attended by representatives of the State Department of Health, the Cleveland authorities strongly urged that the Department of Health take active steps toward the organization of the men interested in the operation and design of water treatment works.

ORGANIZATION

The Ohio Conference on Water Purification was organized in 1921 by the State Department of Health. The first meeting was held at Columbus in November. At this meeting a constitution was

¹ Presented before the Central States Section meeting, August 24, 1928.

² Chief Engineer, State Department of Health, Columbus, Ohio.

adopted setting forth the name and objects of the conference, the details of the organization and the arrangements under which it was to be carried forward.

Active membership was given to those actively in charge of the water treatment plants about the state. In addition, the engineers of the State Department of Health were given active membership.

Associate membership was assigned to those engaged in the design of water purification works and to others in the state officially interested in the objects and aims of the conference. Included in this class were the city officials other than the water purification plant chemists or superintendents.

The officers of the conference consist of a chairman, vice-chairman, secretary-treasurer, editor and two executive committee members in addition to those officers already named. Active members only are eligible to the positions upon the executive committee and to hold office, with the following exception: engineers of the State Department of Health are not eligible to hold office, other than that of editor.

The arrangement whereby a representative of the State Department of Health is editor for the conference has been convenient in several respects: (1) The position on the executive committee, although ex-officio and without a vote, furnishes opportunity to give advice and direction to the work of the conference that is valuable to the Department of Health. (2) The work of the Conference is recorded in publications made available through the state printing agency without cost to the members. (3) A centralized control of the publication and the mailing of the reports simplifies effort from year to year and avoids confusion that would result from changing personnel in this position; also much labor is kept from being placed upon a member of the Conference who could not afford to do the work without extra compensation.

There are no dues to the Conference. Each year a collection is taken at the annual meeting, the secretary-treasurer giving an estimate of the amount needed to take care of certain expenses that are incident to the working of the Conference during the year. Generally speaking each person present contributes the per capita amount estimated to be needed.

The object of the Conference as denoted in the constitution is "to promote the science and practice of water purification; to promote coöperation among the members of the association and the State

Department of Health; and in this way to enable each municipality to benefit from the experiences of other municipalities."

The meetings are held annually in October or November. At first Columbus was chosen, because it was the central point in the state and the most logical one for the first meeting place. Following the first three years the meetings have been arranged at other places, the fourth meeting being at Cincinnati, the fifth at Akron, the sixth at Toledo, the seventh at Cleveland. It is planned to hold the eighth meeting at Lima. The reason for departing from the central location as a meeting place was the suggestion of the membership to hold the meetings where developments of particular importance were under way and where inspection of local works would be of material benefit to the Conference.

It is worthy of note to state that the attendance at these meetings has increased gradually so that now practically all the Ohio plants are represented. This is in spite of the fact that most of the members must pay their own expenses because of state laws and rulings prohibiting municipalities from sending delegates to conferences and conventions. It is expected, however, that the next session of the legislature will rectify this situation by adopting a law whereby the municipalities interested may defray the expenses of the representatives upon certification by the State Department of Health.

THE WORK OF THE CONFERENCE

The executive committee assisted by the State Department of Health plans a program of work each year for a limited number of the membership who are asked to contribute to the annual meeting a paper upon the results of special work. These papers have been varied, some being purely descriptive of experiences at a particular plant which is meeting problems of special interest to the members; or the papers may represent the results of research studies in plant practice or laboratory procedures; or the results of experimental work may be presented that have been conducted on both large and small scale. As a rule the results are from large scale plant researches which are more valuable than laboratory studies.

The programs are arranged so that one day is given to the presentation of original papers and the discussions upon them; one-half day is allotted to round table discussion, questions, topics, "tricks of the trade," "features of filtration, etc.," and a half day is given to inspection of the local filtration works and any special features of research

at that plant. It has been deemed advisable to limit the time to a relatively short period rather than to devote three or four days to the Conference, for the following special reasons: (1) A desire to hold the expense to each member at a minimum; (2) the advisability of limiting the absence of a superintendent from his filtration plant to a short period; (3) the interest must be sustained; (4) experience of the first few years showed that the shorter conference period was the better plan and accordingly the time has been limited to two days at the recent meetings.

The topics considered at the Ohio Conferences have covered almost every branch of water purification practice. One of the earliest efforts was to coördinate the practice of the analyst in the laboratory in following recommended procedures such as given in Standard Methods of Water Analysis. Another effort was directed toward correcting the mechanical detail of water purification operation. Some of the problems considered involved the peculiarities of raw water and the best methods of treating these waters; discussion of efficiencies and limitations of the processes due to the loads placed upon them; standards of quality to be attained; details of design that are desirable to include in new filtration plants. Special features of water treatment have been given attention such as double coagulation, water softening, iron removal. The operators are encouraged to present to the executive committee during the year any phase of water treatment which in their estimation should be discussed at the annual meeting. The executive committee uses its judgment in assigning problems to the operators and tries to respect the personal preferences of the members as well as to keep in view the value of the results to be obtained; and, of course, questions along certain lines are naturally referred to those most skillful in those lines of water treatment.

One of the most valuable parts of the conference work is the publication of the annual report. In the few years which have passed, it has been found that the publication is most valuable for reference and for the establishment of good practice. At first no particular effort was made to take down the discussions literally, but the consensus of opinion was arrived at by one or two taking notes. As the work increased it was deemed advisable to employ stenographic assistance and during the last four years an expert stenographer from the United States Public Health Service familiar with technical terminology has been employed. All discussions are

taken down literally, but it has been deemed expedient to use the abstract form for reporting such discussions. In the publications a feature of arrangement is the placing of an abstract of the paper prior to the abstracted discussion. The reader is therefore greatly assisted in absorbing the contents of the report. For the details of any particular topic under discussion he may turn to the paper in full, listed in the publication as an appendix.

As stated previously the expense of the stenographic service is defrayed by an annual collection; this expense is practically all that is incurred by the conference as an organization. A mailing list of some 500 persons is maintained and each year these names are gone over carefully to ascertain the advisability of keeping them on the list. Included in the publication is a return postal card for acknowledgment and request to be kept on the mailing list.

ACCOMPLISHMENTS OF THE CONFERENCE

The importance of the conference in this state will be appreciated when it is understood that there are 80 filtration plants supplying three million people or about one-half the entire population of the state. One-fourth of these plants soften the water in addition to the purifying.

Since the effort to bring about better water treatment was started an improvement in the quality of water produced has been the result, accompanied by a lowered incidence of water-borne disease. For example, in 1910 Ohio had 25 typhoid deaths per 100,000 and during the 17 year interval up to and including 1927 this rate has been steadily reduced to the present figure of 3 per 100,000 for the state as a whole. It is felt that the reduction has been considerably due to the production of a better effluent from existing water treatment plants.

The accomplishments of the conference include a better local recognition of the importance of water purification; the municipality holds in more respect the man in charge of the water purification plant; and the city officials are now more inclined to give him adequate assistance and equipment by reason of the better understanding.

The chemist or superintendent has also widened his acquaintance and has broadened his education by contact with others in similar lines of work at places in the state where problems of like nature are faced.

The close coöperation of these men in charge of water treatment

with each other and with the State Department of Health has resulted in great benefit to the municipalities and to the state by reason of an increased efficiency of the men at the plant where the water treatment is practiced. It is a fact that the Department of Health is able to carry on the supervision and control of water purification to much better advantage by reason of the annual meeting of these operators than would otherwise be the case.

We feel, perhaps with pardonable pride, that the art of water treatment has been advanced by the work of the members of this conference. The publications speak for themselves with regard to the work done and the conclusions drawn. Recognition has been given by those in other states and in other countries to the work of this group.



A NEW BACTERIA COUNTER

BY AUGUST V. GRAF¹

The details of construction of the bacteria counter in use at the Chain of Rocks Plant of the St. Louis water works are shown in figure 1.

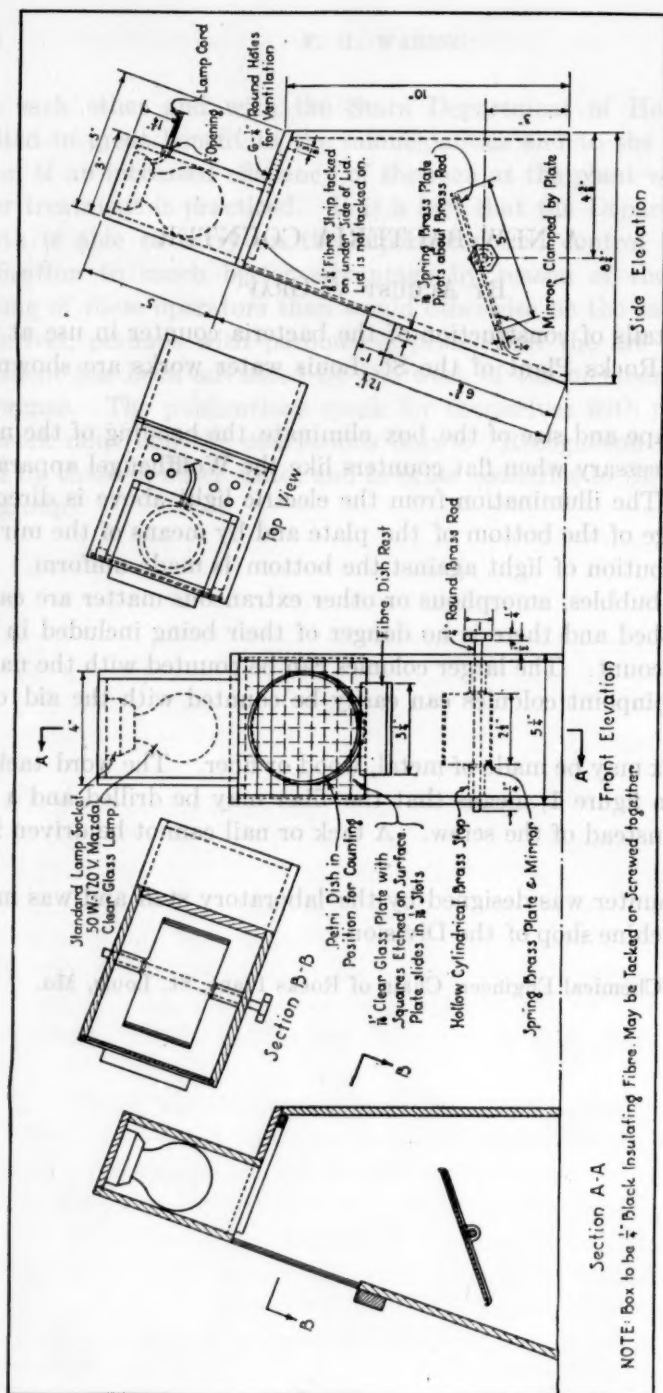
The shape and size of the box eliminate the bending of the neck that is necessary when flat counters like the Wolffheugel apparatus is used. The illumination from the electric light above is directed at the edge of the bottom of the plate and by means of the mirror, the distribution of light against the bottom is made uniform.

All air bubbles, amorphous or other extraneous matter are easily distinguished and there is no danger of their being included in the bacterial count. The larger colonies can be counted with the naked eye and pinpoint colonies can easily be counted with the aid of a lens.

The box may be made of metal, wood or fiber. The word tacked, as used in figure 1, means that the fiber may be drilled and a pin inserted instead of the screw. A tack or nail cannot be driven into the fiber.

This counter was designed by the laboratory staff and was made in the machine shop of the Division.

¹ Chief Chemical Engineer, Chain of Rocks Plant, St. Louis, Mo.



SUPERINTENDENTS' ROUND TABLE DISCUSSION¹

INTRODUCTORY SUMMARY OF PRACTICE

J. WALTER ACKERMAN:² An authoritative answer on the question of cement joints is given in practice in California where it is almost universally used as a pipe jointing material. Mr. Allen Hazen has given me some information in relation to this question and he could not see any valid reason why it could not be used in other localities of similar characteristics. While I believe, in general, that the old type lead joints are being displaced by manufactured compounds that are on the market and have proven their worth, yet if cement will work well in California there appears no valid reason why it should not work in other places, and this would result, I believe, in quite a saving in cost.

Due to fast moving traffic with heavily loaded trucks, collisions with hydrants are bound to occur and usually result disastrously so far as the hydrant is concerned. Some times the truck or automobile goes scot free and the driver, without a conscience, leaves the place without reporting same. The question here is, "What is the remedy?" Several places report the adoption in the busiest districts of the flush hydrant, others advocate moving the hydrant away from the curb and others the placing of protective devices around the hydrant.

"In a metered system, what happens when the meter reader is unable to gain entrance to the building." In general, there is a return of the meter reader to the premises on a pick-up excursion to see if he cannot locate the family at home. If not, a return post-card is usually mailed to them with the request that they mark upon the form printed on the card the location of the dials, or if it is a straight reading register, the exact figures showing in the opening.

"As to the percentage of cost used for depreciation on cast iron pipe, water station equipment, buildings, concrete floors and graveled roofs." It would appear from a review of the figures presented on

¹ Presented before the Toronto Convention, June 24, 1929.

² City Manager, Watertown, N. Y.

this that the depreciation charges are made fairly low. As cast iron pipe is one of the principal items of expense, an examination of replies shows that it runs from one to a maximum of about 2.4 per cent, but, in general, it is evident from the reports that $1\frac{1}{2}$ per cent would be about the average depreciation charge against Class "B" cast iron distribution pipe. With the other items, they vary within wide limits from 2 up to a maximum of 25 per cent for fixed assets.

A practice that is altogether too uncommon is that of making a personal contact with the new consumer. One city presents a form letter which is sent out by the company to every new consumer who takes water. This creates a kindly feeling and establishes a relationship that may later help the superintendent out of any difficulty that may involve a new customer.

A new method of collecting water bills is reported. That is, a city rendering quarterly bills usually has three districts, and they are sent out each month all at one time with a certain number of days allowed for payment without penalty. In the larger cities this results in over-crowding the treasurer's office on the last days for payment. To obviate that each district has sub-districts in which the date of payment is varied for every one of the sub-districts one or two days. In terms of the electrical industry that means that they have a more uniform load factor so far as collecting bills is concerned.

One waterworks has found a new reason for shutting off water. In a case in New Jersey it was ruled by the court that where a dog on the premises keeps the meter reader from reading the meter, the water company is justified in shutting off the service. The court said, "If the complainant (water consumer) refuses or neglects to maintain a condition at his residence admitting of regular meter readings, the company will be justified in discontinuing service and refusing to resume the supply until such condition is corrected."

One of the important questions that is often asked is, "What rental do you charge the city for fire hydrants?" Unfortunately, of course, many of the municipally owned plants make no charge in the general tax levy for fire hydrant use or for general public fire protection. If this is a property benefit it should be charged against the general levy.

The maintenance of the fire department with its apparatus, buildings and equipment is all a general property tax and justly so, but this is but a part of the general fire protection scheme. Without the waterworks with its hydrants, its enlarged mains and works, the personnel of the fire department would be unable to render any serv-

ice. There should always be a charge, therefore, in the general city tax levy for the use of the fire hydrants and the mains, etc. The general question is, how much or in what manner shall the amount be computed. From the replies appended and from the opinion of those who have helped to make our manual of practice a model and guide, it seems to point directly to two factors; one, the number of standard hydrants and the other the inch feet of mains. While the amounts may vary the principle is the same. The gross amount allocated to public fire protection should be determined. The rates should then be proportioned to the amount of inch feet of mains and the hydrants so as to yield the required sum.

"Waterworks forms and their use." The systematizing of all sorts of control accounting for widely different purposes has developed immensely within a decade. In waterworks operation, while progress has been made to some extent, the same advance has not been made that we find in other lines of business activities. Such articles as we find on the development of different systems of bookkeeping and detail will be of great advantage for study in order that accounting control and information may be made available.

"What is the practice with regard to tapping of mains for various size services from $\frac{3}{4}$ to 3 inches?" It would appear that the trend of practice is to use a wet tapping machine from $\frac{3}{4}$ to 1 inch and with larger sizes to cut in a tee or use a tapping sleeve and valve.

In the colder climates, the question of frozen service pipes is always a bothersome matter because the customer who is unfortunate enough thinks he is being discriminated if he finds that his service is frozen and that of his neighbor is still free from the frost. Of course, the reason for frozen services is that they are laid in too shallow trenches and modern snow removal practice makes for greater exposure. In our northern latitudes like Watertown we cover mains and services at least 5 feet. This does not always protect us, however, and during some winters the extreme cold will render large numbers of services impossible of use without thawing. The best general practice at the present time is in the use of one of the small machines operating under its own power and developing current of a proper strength to thaw out the services running into the houses. This is much better practice than the old method of hot water and a pipe line inside of the service pipe. Unless the pipe was laid in exact line or level it was usually difficult to secure proper results with the hot water, whereas, with electricity, it takes but a few minutes to thaw a frozen pipe sufficient to start the water.

The freezing of the service pipe sometimes involves the meter as well. Practice dictates that the necessary repair in such a case should be borne by the user or owner of the building.

Pursuing the meter subject further, not much is found as to practice of owning and setting meters. However, it is generally conceded that ownership should be vested in the waterworks and the waterworks with its own employees should make the settings, first, because of their proper interest in determining the best location in complicated cases and to be sure that all water used should pass through same, and secondly, it can be done at a much lower figure than by plumbers. In a recent experience in my own city, the cost of installing about 2,000 $\frac{5}{8}$ -inch meters averaged \$1.90 per meter, covering all expenses therefore, as follows:

Fittings, including labor cost of cutting threads on piping . . .	\$0.67
Labor cost, testing and sealing meters.	\$0.09
Labor cost installing, including time of foreman, assigning work and checking, material and installation.	\$1.14
Total.	\$1.90

The only item not charged for was use of service truck by foreman. The wages paid the general foreman were 60 cents. Each meter setter was paid 55 cents and each meter setter's helper was paid 50 cents. The average number of meters set each day by each crew of two men was 7.6 in 8 hours.

We call our waterworks a "utility," and first of all it should be utilitarian. Unfortunately, in too many cases it never gets beyond that point, as in general the funds available are all needed for the basic requirements. There seems to be an increased interest in the possible aesthetic values inherent in the building of, or the later development of, the works. Landscaping of the grounds can be accomplished with small outlay, keeping storehouses and yards in a neat condition. All these factors tend to impress upon the public that this quality extends to the product as well. In some places where it is necessary to have elevated water towers they should be made artistic to conform with the surroundings.

The interior of filter plants and pumping stations should be kept in the most clean and orderly way. Even the much criticised polished brass has a wholesome effect, not only on the public but on employees, for in some instances it is almost necessary to provide some such detail to keep an employee busy.

BROKEN FIRE HYDRANTS

MALCOLM PIRNIE:³ The entire extension of a large distribution system in a southern waterworks system was built with cement joints. One of the operators who had to go out and fix damage done to hydrants by automobiles came to me and said "Please change your specifications so that joints between the main and the hydrant will be of lead instead of cement. With a cement joint something goes, and we have to take the whole pipe up." If it had been a lead joint it would usually go out of line without any leak, and if it did leak it would be simply a matter of putting the hydrant in line, and releading the joint.

JAMES E. GIBSON:⁴ In one of our Southern cities, with a municipal system owned by a private corporation, if a hydrant is broken by one of these noted drivers, the city has to maintain it. As a result of that the police department is instructed to pick up the driver. After several years' experience in this municipality they have asked the water company to make the joint between the hydrant and the main with lead.

A MEMBER: We have quite a number of hydrants broken off, and I find that, if the hydrant is not supported the joint will go, but if it is forced backwards it will always break the joint. I do not think the joint has much to do with the breaking off of the hydrant, because most of our hydrants are broken off at the valve.

JOHN COLES:⁵ We have a number of hydrants broken and we find that most of them have been bumped by cars. They are broken off below the ground, and the valve has been broken. We have to put in another valve.

³ Consulting Engineer, New York, N. Y.

⁴ Manager and Engineer, Water Department, Charleston, S. C.

⁵ Superintendent, Water Works, West York Township, Toronto, Can.

WM. W. BRUSH:⁶ We have between 600 and 1000 hydrants broken each year by loaded and unloaded truck drivers and trucks. We use lead joints. The hydrant in every case breaks off at approximately the ground level. As far as I know there is little or no difficulty with the joint. I do not know just what may be the experience with the more rigid form of joint.

Speaking of a subject that will be brought up in a minute, we have concluded that, although it costs \$50 a hydrant, and possibly a little more to replace a hydrant valve, including the labor involved, it is better and in the interest of the community to continue using our hydrants placed at a distance back from the curb of about 18 inches and to use the best type of hydrant, rather than to attempt any special form of hydrant. We do put up protectors around hydrants that are particularly subject to blows from vehicles. In a few instances we have moved hydrants from a location near a corner where the vehicles are likely to hit the hydrant more frequently, to another location, so as to reduce the frequency of breakage at certain critical points. Generally speaking, we have concluded that it is best to do as we are doing and continue with the best type of hydrant we have, and replace them as required.

JOHN COLES:⁵ Where we have a hydrant broken we find that the valves protect leakage and that we have no waste of water in connection with the hydrant.

THE CHAIRMAN: I might mention that in the City of Buffalo we have a good many of those so-called loaded drivers who hit our hydrants. We have one method of finding out who did it, and we offer a reward of \$10 for information as to the number of the car that hits a hydrant. You would be surprised to know the number of hydrant breakers who are detected by the police or by some boy. We have succeeded in 70 per cent of the cases in collecting damages through having the man up in police court, or making the insurance company pay.

JOHN COLES:⁵ Do you add the \$10 to the cost.

THE CHAIRMAN: Yes, and then some.

⁶ Chief Engineer, Department of Water Supply, Gas and Electricity, New York, N. Y.

JOHN CHAMBERS:⁷ We have been using leadite for pipe joints for a good many years, and we discovered very early that leadite would not do for sleeves on account of the very large mass of material, the expansion being so great. We discontinued the use of leadite in sleeves of all kinds.

WM. W. BRUSH:⁸ The 600 to 1000 hydrants represent only between 1 and 2 per cent of all the hydrants in use. We have about 50,000 hydrants.

A MEMBER: I wonder if everybody here heard what Mr. Chambers said about using leadite in sleeves. That is a new idea.

S. H. TAYLOR:⁸ We have had experience in New Bedford along that same line, but we found it was because we poured the whole joint solid. If we make the joint with about 3 inches of leadite we have no trouble. If we pour the whole sleeve full of leadite we find it is a bad practice.

A MEMBER: What method of protection has been found most successful?

WM. W. BRUSH:⁶ The form we have found most satisfactory is to take either a steel or cast iron pipe about 6 or 8 inches in diameter and put it in the ground about 3 feet and fill it with cement or concrete. We have one on each side of the hydrant where it is liable to be hit. we had one hydrant in the Bronx that was broken several times. It was suggested that it should be taken out because apparently the traffic could not avoid hitting it. We replied that it was the air vent for a large pipe line and we could not change the location because it was at the summit. We put in a concrete filled pipe, and although it was hit once or twice by an automobile thereafter it is still there.

THOS. HODKINSON:⁹ We had an epidemic of automobiles hitting hydrants, and we had them placed about 18 inches from the curb, and inside the walk. We placed a valve on each hydrant, and we have had no trouble since.

⁷ Chief Engineer and Superintendent, Louisville Water Company, Louisville, Ky.

⁸ Superintendent, Water Works, New Bedford, Mass.

⁹ Superintendent, Water Works, London, Ontario, Can.

METER READING

THEODORE A. LEISEN:¹⁰ When our regular meter reader is unable to gain access to an apartment or any premises we send a special reader out within a day or two. If he fails to get the reading, and he very frequently does fail, because there are so many cases now where both the husband and wife work and the house is closed all day, we follow up by sending a special reader around after 5 o'clock in the evening. Another method we use is to send out a card by mail with a return stamp asking them to read their own meter, and indicate the reading on this card. If they fail in a week we send a man out at night, and if necessary on Sunday. In that way we always get the information.

A MEMBER: Is there an extra charge made in a case of that kind?

MR. HODKINSON:⁹ We follow the same practice that has been described by Mr. Leisen. We have found lately that both the husband and the wife are at work during the daytime, and by sending these special readers we are able to get the information we desire. We read the meter quarterly, one section on the first of January, on the first of February, and another on the first of March. Some meters are skipped at certain intervals. Sometimes people are away during the winter period and in these cases we read the meters every 3 and sometimes every 6 months.

JOHN J. GAFFNEY:¹¹ We have one man who is specially employed to look after meters where they cannot get a regular reading. We send him out in the same way as has been described.

We have just completed a study of what we call back reading. We have introduced a system whereby the reader leaves a card on the premises saying he will be back again the next morning between 9 and 10 or 10 and 11. This man has the reading of about 125 meters and we know just about what time he will complete that reading every day

¹⁰ General Manager, Metropolitan Utilities District, Omaha, Neb.

¹¹ Bryn Mawr, Pa.

and the time he will be back the next morning. If he has ten return calls for one day these will be his first calls the next morning. In some cases he asks the people to read the meter and he will call for the reading the next morning. If they are not home they will leave it for him by placing it on the back window. For several months we tried the system of having special readers, but we found it cost us too much money. We then adopted this "callback" system. We also send cards by mail, and we find that we get 65 to 70 per cent of them returned. We point out to our water users that, if they do not make their payments regularly, the next time it will be a double payment, or a very much increased payment on their bill. When you appeal to people in that way they will generally respond. That system was very successful and 90 per cent of the readings came in. We had then only 10 per cent to look after. We had only six or seven days to get these callbacks in before we closed our books. If we do not secure the reading by postcard we issue a bill for the service, and call the attention of the customer to the fact that, if they return the card and give the reading of the meter, we will bill them in that way. This has worked wonderfully well. Where the territory is scattered we have to use an automobile, and that is very expensive.

THE CHAIRMAN: What do you do about the curbstone reader.

MR. GAFFNEY:¹¹ I have had experience with the curbstone reader. I find that the only way to avoid it is to have a supervisor of meter reading. We call back the next day and ask was the meter reader there, and sometimes they will say I do not know, but perhaps my little girl will know. She will say "Some man was here and left a paper." Checking up with the people on the premises is one way of checking up the curbstone meter readers.

THE CHAIRMAN: We had to go a little bit further in that regard and make a double reading. We asked the owner of the premises to advise us whether the meter reading is correct or not, and we have had customers call up at the office and say that they did not get the reading slip.

MR. HODKINSON:⁹ The most important time in regard to the curbstone reader in this part of the country is during the winter, and that is the time when we get most of that work. About the latter part of

December we take a reading of all meters, and we take it again on the first of March. It is between these times that we find the curbstone reader.

A MEMBER: We read about 200 meters a day in Philadelphia.

A MEMBER: I wonder if there is any trouble with the foreign residents in reading meters.

THE CHAIRMAN: We do not have any trouble because our meters are all the direct meter type. The electric company does the same thing, they send out a card and have the customer check the reading of the meter.

DEPRECIATION RESERVES

MR. LEISEN:¹⁰ I do not know that what I say on this subject will be of much importance except as representing a municipally owned corporation. We make our depreciation honestly. We take the depreciation on the buildings and the pumping stations and then we arrive at what seems to be a fair average depreciation to charge on each item separately, and we charge up the whole thing. We do try to get as near an honest and fair rate of depreciation as we possibly can, and all our accounts carry that depreciation every month.

THE CHAIRMAN: What is your average?

MR. LEISEN:¹⁰ I think it will average about $4\frac{1}{2}$ per cent on the total value of the property.

A MEMBER: Pipe lines and all?

MR. LEISEN: Yes, but it is lower on the pipe lines than on the pumping station and other equipment.

JOHN CHAMBERS:⁷ Our water company is honestly owned, and we also try to be honest. We have a depreciation charge of 1 per cent on all things with the exception of the trucks and other items of that kind. That 1 per cent includes real estate, pumping stations, and other things of long life. I think you will find 1 per cent is enough except for perishable things.

A MEMBER: The gentlemen from Louisville places 1 per cent straight depreciation, but they do not have to pay any taxes.

JAMES E. GIBSON:⁴ My experience agrees with that of Mr. Chambers. We charge 1 per cent depreciation, and set it aside monthly in a separate fund and allow it to accumulate at interest at 4 per cent. I have been able to invest that depreciation fund in bonds that will yield us 4 or a little over 4 per cent. Automobiles and things of that kind we charge directly to operation. At the end of each year we

inventory automobiles and tools, and value them and credit the operation for that year with the salvage value. In the case of automobiles we charge an operation figure monthly based on the consumption of gasoline by these machines. We tried the mileage basis for a few months, but we found the speedometers were not accurate or somebody would have them disconnected. We now simply work out the charge on the basis of gasoline. If a car uses so many gallons of gasoline, we fix the charge per gallon of gasoline, and charge it to the operating account, so that our automobile operation of the year just about equals their depreciation value. That is, the value at the beginning of 1929 less earnings will give about the salvage value of 1930. We charge 1 per cent on the gross cost of the plant, including land. You all know that land will appreciate if it is in a good community. That 1 per cent set aside monthly is drawing interest, and it will reproduce your plant in about 40 years. If you maintain your plant in good condition you will get a 40 year life without any question. Of course, we carry maintenance as a straight operating charge.

A MEMBER: We do not set aside our depreciation fund in that way. We simply debit or credit it, and do not set it aside in cash. I think that is the more modern way of doing it.

MR. GIBSON:⁴ We are a municipal plant, operating under a legislative act. When we took the plant over we decided to set aside depreciation, and we are doing it religiously. Two years ago we were subject to a severe test because we had to get more water. We have made all our improvements from our income without asking for an issue of bonds. We thought we have full legal powers to create a debt to maintain our water supply. It cost us a half a million dollars to obtain the additional water, and after careful consideration and advice with our bankers and board, we found that we could carry this amount by issuing \$300,000 worth of five-year serial notes. We consulted our lawyers, and they advised us it was absolutely legal, but when we came to sell these notes a few of the bankers competing on them raised the question of their validity. In the meantime we had gone ahead and made our contract and the contractor was actually working. We trumped up a suit in the Supreme Court and to our chagrin the Supreme Court said we could not create such a debt, although we pointed out to them the bond issues that were validated. That was even a more direct violation of the statute than the note

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issue. We did not pledge the plant or the city in these notes, but we did pledge the excess profit over and above our actual operating expenses, which was estimated at about \$100,000 a year, but the Supreme Court said you cannot do it and we were up against it. We had at that time something like \$260,000 in our depreciation account, so Supreme Court or no Supreme Court we have borrowed \$260,000 from the depreciation account to pay for the work we are now doing.

A MEMBER: You set aside 1 per cent a month for depreciation?

MR. GIBSON:⁴ No, 1 per cent per year set aside monthly.

THE CHAIRMAN: Speaking about setting aside depreciation on the total cost of the plant, I had occasion to examine a report written by a holding company covering some 26 plants. The depreciation item was from 0.2 to 0.9, with an average of 0.7 per cent. These were private people who wanted to make a showing. When you come to the income tax collector, you will find that you will be allowed from 3 to 5 per cent. In a municipal plant the depreciation question is quite easy, because it is just a question of what depreciation should be set aside, as a net result of the cash on hand.

H. GORDON CALDER:¹² I want to talk about accounting devices for a few minutes. Our federal income tax man is very interested and has frequently sent out letters to several private companies in connection with depreciation for Federal taxation purposes. As a matter of fact you can set up on your books one rate of depreciation on an engine or any other piece of machinery, but you will have to take whatever the Federal Government will give you. It does not have to be reported, however, as against your earned surplus. It is part of your depreciation expenses. You may make divisions on your books, but the Federal Government will not allow you to take that as expenses. They will allow you to make a certain rate of depreciation, but you have to put it on your books as depreciation. There are dozens of proper ways of handling depreciation. You can have two methods, one for your Federal tax return, and one for your actual surplus statement. This is one of the things that Mr. Omerod is going to cover in his next paper. We are asking the coöperation of all water companies on the proposition of setting up depreciation. If you take depreciation it must be recorded on your books and then the question arises which account will you put it in.

¹² Assistant Comptroller, Federal Water Service Corporation, New York, N. Y.

THE GOOD WILL OF THE CONSUMER

W. S. PATTON:¹³ The best way to handle your consumer is to have a good looking girl at the inquiry window. You cannot beat that combination if she has a nice face and a soft, pleasing voice, because the customers will go away smiling after they have made their complaint. I would rather have a woman handle my consumers than a man. Of course, I always have a man handy so that when it comes down to an argument he is there to explain things, but when you are taking the consumer's money I think a pretty and sweet girl is a combination that cannot be beat.

THE CHAIRMAN: Is there any work being done towards presenting to the consumer the facts relating to the charges and how they are made up.

W. S. CRAMER:¹⁴ We have a lady cashier and a man cashier, and they work side by side. The man takes care of the lady customers and their complaints, and the lady takes care of the gentlemen customers and their complaints.

MR. GIBSON:⁴ I have found that when you have a dissatisfied customer in 99 per cent of the cases the best thing is to let him have his say. There is an old saying that if you give a calf plenty of rope he will hang himself. That will pretty well work out in the case of a dissatisfied customer. If you can get him to talk and talk and after he is run down, open up your battery, you will find that the problem is 75 per cent decided. Of course, sometimes the women folks never do run down, but I agree with Mr. Cramer that it is a good thing to have a gentlemen look after the complaints of the ladies. I think it is a great mistake to try to argue with a dissatisfied customer.

A MEMBER: We have few complaints. We have a high rate and a low rate, and we send a man back to reread if the rate is high. We let the man see that we are trying to play square with him, and we will sometimes reduce his rate.

¹³ Ashland, Ky.

¹⁴ Vice-President and Manager, Lexington Water Company, Lexington, Ky.

MR. TAYLOR:⁸ We send our bills out quarterly, and we read the meter monthly. The object of the monthly reading of the meter is to see that the meter is registering properly, and if we have a very high reading we will notify the customer or leave a card asking them to examine the meter and see if the reading has been correctly taken. Sometimes we send a man to examine the premises, because in that way you will frequently discover a leak. It makes the customer feel satisfied when he discovers that you are taking an interest in his supply.

THE CHAIRMAN: Some years ago our office staff consisted entirely of men. When a customer came in and saw all men there he would become angry in making his complaint. We decided to employ ladies to collect the bills just for that reason, and we found that it made quite a change. It is a difficult problem to solve when your customer has a bill for \$10 and the next one is for \$90 and I think it is better to adjust that bill. That customer will never be satisfied if you make him pay that bill, even if you are sure that the water has been used. Do not make the mistake of settling these big bills yourself, or you will have a lot of trouble. The best way is to refer them to somebody else and let them do the settling. We had one customer who came to us frequently with complaints. He had tenants and he never looked after them. We have a practice that when we have a large bill like that in a complaint we issue what we call a customer's complaint, irrespective of whether any complaint has been made or not, and we try to find the reason for the big bill. Usually the girl in the office can make any adjustments when a complaint is made. The heads of departments have no right to give any favors to one customer or another. If one taxpayer uses water carelessly there is no reason why all the rest of the taxpayers should stand the brunt of his carelessness or dishonesty.

MR. GIBSON:⁴ I agree with Mr. Huy that it is very poor policy to make adjustments particularly in a municipal plant. I take the position that in the municipal plant your duty is to serve the public. If you show consideration for one man you should do the same to all. In a private plant if you show consideration to one man, you are simply giving the money of your stockholders away. In a municipal plant you are giving away the municipal funds. At Charleston, a number of times the question has been raised of rebating a high bill

as much as 50 per cent. In every case our attorneys have advised us that that is discrimination and cannot legally be carried out. We have three commissioners on the Commission who have paid \$90 water bills. When they come to me and ask for an adjustment I tell them that one of the Commissioners has had to pay a \$90 bill and that I have no authority to make an adjustment. If they would like to bring the matter before the Commission I would be glad to have that done. Of course, when the matter is brought before the Commission the consumer receives every courtesy and consideration, but the complaint is disposed of in the usual manner, which means that the consumer pays the bill. In one or two instances of these high water bills the consumer does not pay it all at once, but he pays it in small amounts, \$1 a quarter, and if he keeps on paying he will get it settled in about 12 years. It usually works out that after he has paid two or three months he gets tired doing that and he wipes out the bill.

MR. LEISEN:¹⁰ The original question was that of courtesy and good will. I think we all realize that large bills are the paramount factor in dissatisfaction. Originally we used to read the meters and collect monthly all our water bills. Before I went to Omaha they changed over and read the domestic meters every three months. As a consequence where a leak occurred that was inaudible and invisible, they would make a two-thirds reduction on the bill. Later on we changed that to a two-thirds reduction assuming that the leak had been found the first month. It makes no difference whether the consumer is a poor laborer or a millionaire, we make the same reduction. In addition to that, whenever a meter seems to be running a little sloppy, and what we think is beyond normal, we notify the tenant that the bill is abnormally high and suggest to him that he look for a leak. We send our inspectors out to find out if there is a leak. I think the biggest factor in regard to courtesy and goodwill is to have a perfectly fair and open discussion with the party who comes in making the complaint and explain to the very best of your knowledge and with patience all the facts in connection with the matter. Try to show him why his bill is high. I think an explanation goes a far way with a reasonable man. Another strong factor is to have employees who have a pleasant manner and a nice method of explaining things.

A MEMBER: We find one of the best methods of explaining to a customer the reason for a high bill is to check his meter, and follow

that up by sending an experienced man to look it over. He takes the customer to the meter and shows the water being registered on the test dial. To show you how it works, we had one of our railway companies that had a 2-inch hose that was left lying on their platform. Several million gallons were wasted in thirty days. The management were not aware that that leak existed. We investigated the matter and found the leak. We found that the man who looked after the water supply had repaired the leak, but we sent the bill into the railway company. Word came back that the bill was out of all possible bounds, and then we gave them the time and date when the leak had occurred and that settled the matter. We have had similar cases in domestic services. Flush tanks in houses are a common source of trouble because a leak of that kind is something that the householder cannot see, but our expert can take the customer to that tank and show him where the leak is, and show him how it is registering on the meter.

S. B. MORRIS:¹⁵ Some one in the organization ought to assume responsibility for these matters and settle them there and then. I think the facts should be looked into and the matter thoroughly investigated and before our customer gets to us with a complaint we have the facts looked into. When the customer comes to me I can make what adjustments are required.

JAMES SHEAHAN:¹⁶ I have heard a great many things about meters and I want to tell you something that happened last year to one of our best customers, whose bill jumped from \$1 to \$15 in a month. He came down to see what was the matter, and we called on the old gentleman and asked him what he had done and he said nothing at all. The next month the bill was still \$15. We sent a man out to look at the meter. While he was there a man came along with a load of watermelons, and the old gentleman bought one of these melons. Our man said to him, how do you cool that melon, and he said I set it up in the sink and turn the faucet on and let the water run all night; so he paid his \$30 for the two months. We rebate all bills that are too high if it can be shown that there is some reason for it. A customer came into the office the other day and talked to the young man who was in charge. He said his bill was \$13 and it had never

¹⁵ Chief Engineer, Water Department, Pasadena, Calif.

¹⁶ Memphis, Tenn.

been over \$2.25 before. He wrote a letter to the Commission and it was referred to me. He came in and I said to him I understand you are real mad about this. I said sit right down and give me all the excuses you have and when you get through I will begin to talk. He commenced to laugh and he said what do you want me to do. I said I want you to go back to your house, and in the morning I will send our man out and he will take your meter out and take it to the testing plant. If that meter is 2 per cent high we will give you this \$13 and if not we will make you pay the whole bill. If the meter is wrong we will not charge you. He did not know about that, and I said, do you know what caused that meter to register that amount of water, because meters seldom make mistakes. We sent the man down and found that the meter registered $\frac{1}{4}$ of 1 per cent under. We charged him the regular rate and split the difference on the other, and that was perfectly satisfactory. We had one case about five years ago where a man had three houses on one meter, and his bill had been running \$15 to \$18. We could not find what was wrong and he had his entire pipe line taken up. He finally found there was a leak in his flush tank that nobody knew anything about. I do not believe in giving a rebate for one or two months, because if you tell a man that you will rebate one time, he will come back for a rebate again. Is there any one here who has the system of leaving a card at the residence where the people are not at home, and have the customer fill out the reading of the meter.

MR. LEISEN:¹⁰ We do that both for water and gas, and that is followed up by a night or Sunday call. We get probably from 75 to 85 per cent of the cards back.

JAMES SHEAHAN:¹⁶ There was an old rule in our Department to compel our consumers to lay their pipes 18 inches underground in the cellar. That was in the early days. In about 50 per cent of the cellars the soil will vary. We find that leaks will occur in these pipes underground. We had one man who was troubled that way and I thought he should get consideration. Our board has reasonable discretion in matters of that kind and tries to make a uniform 50 per cent allowance, but not the whole bill. We charge the consumer the amount of his former bill and allow him 50 per cent of the excess bill. I believe the bills that are sent out are pretty nearly correct. We have one man who pays a bill of \$396 or \$450 a quarter without any question.

HARRY F. HUY:¹⁷ We had one meter that worked backwards. I asked the meter expert if it was sealed, and he said yes. We sent the meter back and we told him that the meter ran ahead for a while and then turned around and ran back. What happened to that meter was that the water passing through it had worn one bearing and it would start to register in the right direction and then with the speed of the water passing through it would work in the opposite direction.

MR. SHEAHAN:¹⁸ We have been reading our meters every month, but have changed it to every two months. We do not allow the same meter reader to read the same meter twice. We change them about.

A MEMBER: I have just been wondering whether we have been talking on the subject of the relation between the company and the customer, or whether we are drifting into a discussion on meters. I would advise you not to wait until you have an actual complaint before you do something. We send out notices advising our customers to take care of their meter, and we encourage our customer to send in the meter readings. The best thing to have is a satisfied customer. One gentleman said his business was to make money for his stockholders. I think he should also try to please his customers. If you can make a friend of your customer by making a little adjustment I think that is good business. Even though you feel that the water has passed through his meter, if you can convince that man that his meter is accurate, is very seldom wrong, and it is frequently tested and that there must be something on his property that is causing the excessive bill he will generally look into it, and be satisfied.

THE CHAIRMAN: I agree with you to a certain extent, but supposing you have a community of 26 different nationalities, you cannot very well send out circulars in 26 different languages. I sent a circular to the Polish people one time and I went to the Priest to frame the letter setting forth what I wanted to bring to their attention. I found that I had to write a different letter to a lady if she was married than if she was single, and I also had to write a different letter to each man according to the position he occupied, and I decided that I could not send out a circular to these people. I think the best way is to go to the man's house and show him why his bill is excessive.

¹⁷ General Manager, Western New York Water Company, Buffalo, N. Y.

MR. PATTON: Before any bill can be adjusted you must make a careful examination to find out whether the water has been used or whether it is due to a leak in the pipe. If there is no evidence of negligence or carelessness on the part of the consumer and no one is to blame for the leak then I would make an adjustment and bill him for the average amount of water at the average rate, and then adjust the difference between that and the amount of water that has gone through his meter. If a consumer has had a leaking water closet, or any other tap in his house he is not entitled to any other consideration.

A MEMBER: If we have a customer who has an excessive bill we send him a postal card and notify him of the high bill he will receive and ask him to look into it and see if there are any leaks. We find that that does more good than anything we have been able to do.

A MEMBER: I think that the charge made at Valparaiso is reasonable. I do not think they are getting too much for the hydrant. I do not believe we can get down to any exact figure as to what the city should pay for each fire hydrant. It is a well known fact that a very large proportion of the money invested in hydrants is caused by a reason of being able to supply that large quantity of water at a time when there is a fire. If you are building your water system purely for domestic use, you would save from 30 to 50 per cent of your expenditure. There is no question as to the justice of the charge, whether the system is municipally or privately owned. The water is supplied to the city and they should pay for it. The money collected from a water consumer should not be diverted to general tax purposes, because if you do, you are distributing your taxation in an unequal and unjust manner.

MR. PATTON: We pay 500 per hydrant and are not supposed to place them 100 feet apart, but the total amount to be levied for the hydrant rental cannot exceed 3 mills on the assessed valuation of the

FIRE HYDRANT RENTAL

E. W. AGAR:¹⁸ The subject of hydrant rental and how much water should be supplied to the city that owns the utilities is an interesting question. We charge \$30 a year for our hydrants and we install a new hydrant for each 500 feet of water main. I would like to know whether that is above or below the average. I have spoken to several members and they say we charge too much, but we need the money to rehabilitate our plant. If we have a surplus in our water fund should the City receive that surplus? What is the difference between the regular fund raised by taxation and the water fund created by the consumer? The question of hydrant rental is a question of what water is used by the fire department for street sprinkling and flushing. These are all serious questions. I am sure that some of you convert the water funds to city funds. In Indiana that is a direct violation of the law.

A MEMBER: I think that the charge made at Valparaiso is reasonably fair. I do not think they are getting too much for the hydrants. I do not believe we can get down to any exact figure as to what the city should pay for each fire hydrant. It is a well known fact that a very large proportion of the money invested in bonds is caused by reason of being able to supply that large quantity of water at a time when there is a fire. If you are building your water system purely for domestic use, you would save from 30 to 50 per cent of your expenditure. There is no question as to the justice of that charge, whether the system is municipally or privately owned. The water is supplied to the city and they should pay for it. The money collected from a water consumer should not be diverted to general tax purposes, because, if you do, you are distributing your taxation in an unequal and unjust manner.

MR. LEISEN:¹⁹ We get \$60 per hydrant and we are supposed to place them 400 feet apart, but the total amount to be levied for fire hydrant rental cannot exceed 3 mills on the assessed valuation of the

¹⁸ Superintendent, Water Department, Valparaiso, Ind.

city. That has been reduced to 0.6 mill because some years ago they used to base the valuation for taxation purposes on 20 per cent of the value of the property. They have changed it to 100 per cent, making it five times as much. That is the reason they made the change.

WM. W. BRUSH:⁶ We find there is a very wide variation in the practice of charging for hydrants and it is difficult logically to support some of the practices. In New York City we have a number of private water companies supplying the great City of New York and fire hydrant rental is carried by direct taxation levied on the entire city. I would not defend that as a sound policy, but the theory seems to be that the people who are receiving the water from the private companies are paying their proportion of the cost of whatever may be excess charges on the water system over and above the amount collected. Therefore, because they have been served by a private company the cost of fire protection is properly distributed over the city at large. The rates defined as properly payable to the private companies for the fire hydrant rental, including water furnished to the hydrants, has usually been found to be between \$40 and \$50 per year per hydrant. That has not been accepted by our Comptroller and various claims against the City of New York are now being considered, and I hope in the process of ultimate adjustment. In order to determine the hydrant rental, it is our practice at the present time to assume, as Mr. Leisen has said, that the primary purpose of the water supply system is to furnish a domestic supply. By laying out what would be a system that would furnish an adequate water supply for present domestic demand and for reasonable future demands, let us say from five to ten years, such a plant could theoretically be built for a certain sum. The cost can be computed as to its present cost and its reproduction cost less depreciation. If a main was laid in a certain street on a certain date and a similar main would have to be laid on that street to provide a domestic supply, that main is computed as to its present value on the assumption that it would have been laid on that street when the original main was laid. The distribution system represents the most important item in the cost. That computation is followed through with virtually all parts of the system. The designers go through the entire system and determine what would be its present value as a domestic system properly laid out to meet the present and reasonably prospective future demand. Then they determine the present-day value of the system as it stands.

The difference is what is attributable to fire protection. Then a determination is made of the allowance or the return that should be earned on such a system, including the operating and maintenance cost and depreciation. That sum total divided by the number of hydrants represents the annual charge per hydrant.

In the opinion of the speaker that is the logical manner of determining the amount that the hydrant properly represents in the value of the unit.

If one quarrels with the fundamental assumption that the domestic system is the basis upon which the plant is established, of course, what comes after must necessarily be discarded, but if one is willing to assume that the fundamental principle is sound then, if the method is followed, the result is correct and sound. The City of New York does not pay anything to the water department for its own hydrants. In that part of the system which is a strictly fire extinguishing system we have three separate fire extinguishing systems located in different parts of greater New York. The entire cost of maintenance, operation and depreciation reserve are met by a general tax levy. Again there we have two different opinions as to the soundness of that method, but it has been accepted without any dissenting voice, as far as I know, by the people of the City of New York. The water funds in one Borough are used for the maintenance and operation of the system for that particular borough. Otherwise the funds are used for the purpose of meeting interest and sinking fund charges, and the surplus, if any, goes into the general tax fund. If there is any lack of funds from the revenue it often has to be met by a tax levy. My salary is paid very largely from tax levy funds, part of it from the Brooklyn water revenue, part of it by corporate stock funds, but mainly from taxation. I look after the water system including all Boroughs. There is no danger from that system as far as New York City is concerned because of the general financial system which New York City adopts. I do not advocate it as being a desirable system. I believe the time will come when we will allocate these various charges and carry on our municipal business very definitely and more properly in accordance with the cost of the different parts of the services rendered to the different parts of the municipality.

MR. HODKINSON:⁹ Mr. Brush represents the largest waterworks system in the United States or Canada, and I represent one of the

smallest. We charge a hydrant rental of \$25 and \$25 for a private hydrant, and \$30 for a sprinkler system. We have practically a 100 per cent meter system. May I ask Mr. Brush if he carries in his mind the percentage of the cost of the system for fire protection to the total cost.

MR. BRUSH:⁶ I have been trying to think what that percentage is. We have made a determination for at least three of the five private companies. My recollection is that it is around 18 to 20 percent. I have had it stressed to me by members of our own department "Well, Mr. Brush, would it be possible to tell us what the hydrant rentals are and what is a fair price to be paid by the City of New York." I think it is absolutely incorrect to take an average. You are taking the average of a great many different communities. It is a question of what is the reasonable and proper cost of the service rendered, and each and every plant must have a separate valuation.

A MEMBER: The water department pays the cost of the installation of the hydrant and the maintenance of the hydrant. I do not yet see the relation that exists between the fund created by the water department, the water consumer, and the one created by taxation. Is it not a fact that after operation and maintenance and a proper depreciation fund is established and a proper fund for new additions, if there has been a surplus it should be reflected in a lower water rate to the consumer and none of these funds should go to the general fund of the city. I do not yet see why any water fund should find its way to the general funds of the city.

MR. BRUSH:⁶ I would say that is absolutely sound. I do not advocate our system except where you are serving a very large number of people who are accustomed to have their business transacted in a certain way, and seem to be satisfied with that way. Our administration is elected on the basis of candidates that are presented to the people by a political party. The control of that political party is in the hands of men who are interested in the welfare of the City, and in the advancement of the interests of their party from the viewpoint of continuing to serve the people by being reelected. You would hardly expect a private enterprise carrying on its business in an advantageous manner to the stockholders and in pleasing the stockholders in the returns that it obtains to decide to change their

system of bookkeeping so that the stockholders would become so incensed against the directors and officers that they would put in a new set of officials and directors. Therefore, there is a good deal to be said for the practice of carrying on a very large system that has been going for many years in a certain way rather than to make extensive changes which the consumer will never understand. You cannot talk to him about it and he will be very resentful of the change. Because the man whose bill is increased is your enemy, and the man whose bill is decreased only gives you credit for what is ahead and not for what has passed, he is not going to be particularly your supporter because his bill has been decreased.

MR. GIBSON:⁴ I think there is a great deal in what Mr. Brush has said. Nevertheless I think the time is coming rapidly when the method of doing business as a country cross-roads grocer and merchant is going to pass. If the wife of the country grocer wants a dress she walks into the store and gets it. If she wants a ham she walks into the store and takes it, but the store is never credited with these goods. It is all in the family. That is the way municipal accounting is done in waterworks systems. I have no quarrel particularly with diverting the funds. I do not think it is proper. But I do think the city should pay for fire hydrant rental, and ought to pay for street sprinkling and for any water that is used for other purposes. I think there should be a careful accounting of the various services supplied to the city. Of course, highways must be publicly owned and you cannot expect revenue from playgrounds and things of that kind, and all these things must be carried on by a modern municipality. Demands are increasing all the time for better policemen, better fire protection, and for other service.

From a logical standpoint, there should be no diversion of funds unless you can conceive of a utopian ownership of property in which every citizen has the same amount of property and wealth and uses the same kind of water. It would then make very little difference whether taxes or water rates were raised.

MR. MORRIS:⁵ One thing that has not been mentioned is the distribution of the cost of furnishing fire protection. In California that has been done, and they have arranged it at so much per mile of main, and have gone about it in the way Mr. Brush has explained. The only defensible method of determining the cost of a system is to

take the cost of a similar system not furnishing fire protection and the cost of one which does. Then the number of fire plugs furnished is determined and allocated to the size and length of the water mains.

THE CHAIRMAN: That is an interesting phase in communities that supply a certain area. We had one township that had to pay \$40,000 a year and yet they did not have a fire hydrant. We have 300 miles of pipe and miles and miles of them are laid through communities where they do not use any of the water.

A MEMBER: I should like to hear an expression of opinion as to what the practice is in charging hydrant rental to private companies, that is, where they have a fire service. Do you make a charge for fire plugs placed on private property if the consumer pays the cost of installing the service?

A MEMBER: We make a charge for fire service based on the size of the service or on the size of the industry to which the service is supplied. The consumer pays the entire cost of putting that service in and he saves his plant a great deal of expense in a reduction of his insurance charges. For that reason he should pay a special service charge.

MR. GIBSON:⁴ We use the same system as mentioned. We make a yearly charge and the consumer can put in as many hydrants as he desires. In the case of hydrants we install a fire underwriters' type of meter to prevent the abuse of that service. I think where any person receives the benefit of a system of that kind it is nothing but reasonable that he should pay for it. In the case of a sprinkler service in a building we make a very low annual service charge for sprinklers where nothing but sprinklers are connected. In that case we do not install meters and the cost is low. We feel that a sprinkler system reduces the fire hazard all over the city. It is a "johnny on the spot" service, and a few gallons of water might protect the whole city, and the fire department might have to use an enormous quantity of water if that fire were not quenched at the beginning.

THE CHAIRMAN: A private company operates in Buffalo. They make a service charge to manufacturing plants having hydrants installed within their property line of \$25 per hydrant. If they want

a fire hydrant they have to pay for it. If they want more than one hydrant they pay \$25 for each and \$10 for each sprinkler head. We have found in many large plants, like the Bethlehem Steel Company, that sometimes they want to put a hose on and they do so. We have other companies that have 40 hydrants in their plant and we charge them for the water that passes through their system. To make no charge on a fire line is very often a cause of loss of revenue.

A MEMBER: Is that \$25 a year an annual charge?

THE CHAIRMAN: Yes, and \$10 for each sprinkler.

CHARLES R. BETTES:¹⁰ We have the largest water system in New York, and we charge \$15 a year for hydrants and furnish all the water. We have our water rates to consumers down so low that we are ashamed of them and now we are worried about the money we have on hand. We have \$62,000 on hand and we do not know what to do with it. We have built lines of 8-inch pipe for miles and we are building a reservoir that will hold 5,000,000 gallons of water. We are putting a cover on it, and we have paid for that out of the earnings of our plant. I would like to know if the city has a right to take this money away from us, because it is real money that we have earned. If we could get \$25 for a hydrant we would take it.

A MEMBER: I represent a city of 15,000 population and most of our local improvements are paid under the local improvement plan. We have never charged anything for hydrants. I would like to know, now that our local improvement funds are running out, what would be a fair charge to make for hydrants.

¹⁰ Long Island Water Corporation, Far Rockaway, L. I., N. Y.

FROZEN SERVICES

MR. HOPKINS: We put our service lines down to four or five feet, that is, below the frost line. If our services are put very close to the top we find they are frozen during the winter. When we started plowing the streets and taking the snow off we find that the pipes freeze quicker. Now we insist that all pipes must be put below the frost line.

A MEMBER: We always put our service lines five or six feet below the ground level.

A MEMBER: How do you thaw them when they freeze?

A MEMBER: They do not freeze up.

H. H. MARTINDALE:²⁰ We have a frost penetration of seven feet and we give our pipes a minimum covering of six feet. We lay our water mains in a seven foot trench. We do not have many frozen services, but if we have any we maintain a transformer that we use for thawing out the pipes. In the case of the freezing of a service we send this apparatus and they can thaw the service out in from two to five minutes. The actual time in getting the apparatus back to the yard again will be probably two hours. We think the electric thawing apparatus is the best. It costs us nothing for the current because it is run by our own line. Seven feet is the maximum of frost penetration. We have sand, clay, gravel, and solid rock. We have about ten miles of paved streets.

A MEMBER: Do you find any difference on the paved streets?

MR. MARTINDALE: Yes, our greatest penetration of frost is on the paved streets.

Our theory is that street services should be looked after by the department, because the plumbers cannot be relied upon. They will

²⁰ Sudbury, Mass.

put the pipes in of insufficient depth. Sometimes they are in a hurry and put them in any way. We put our services seven feet underground, and once in a while in a gravel stratum we will have a bad spot.

MR. LEISEN:¹⁰ We lay our services five feet deep. Last winter was an extremely cold one, but we only had two or three services reported frozen.

THE CHAIRMAN: Have any of the members had any experience on a gasoline pipe thawing apparatus?

A MEMBER: Our average is \$1.50 to \$2.00 for thawing. We use an electric transformer.

If there is a dispute with a customer as to the location of the frost we pass a fish wire into the service pipe and locate where the frost is. In that way we prove who should pay for it. If it is on the customer's side we make him pay for the thawing.

METER OWNERSHIP

Mr. GIBSON:⁴ The water company should own the meter. The customer should not pay for it. The water company should own and maintain the meter just the same as they do a cash register.

Mr. LEISEN:¹⁰ We own all water meters and we charge for the installation, but in no case do we charge for the meter. I think the meter is the most important part of the system as far as the revenue producing element is concerned. For that reason we want to own and maintain them properly.

Mr. TAYLOR:⁸ We give the owner the option of owning the meter or paying a rental. I should say that about 80 per cent of the meters are city owned. Our experience has been that it is much more satisfactory to have the meter owned by the city than by the consumer.

Mr. COLES:⁵ We install the meters and maintain them and we charge a rental of fifty cents per month.

STATEMENT OF FINANCIAL CONDITION, YEAR ENDING DECEMBER 31, 1928

ASSETS		
Cash.....		\$969.72
Accounts Receivable:		
Advertising.....	2,599.50	
Less Annual Dues advance payments..	255.91	2,343.59
Investments.....		14,186.75
Office Equipment.....	1,438.29	
Less Depreciation.....	143.83	1,294.46
Inventory Manuals.....		93.75
Total Assets.....		\$18,888.27
Surplus (last report).....		\$17,632.51
Net addition to surplus for year ended 12/31/28..		1,255.76
		<u>\$18,888.27</u>

STATEMENT OF INCOME AND EXPENDITURE

Income:		
Initiation Fees.....	\$1,114.61	
Annual Dues.....	28,238.25	
Advertising.....	18,021.67	
Subscriptions to JOURNAL.....	1,854.46	
Sales of JOURNALS.....	154.35	
Sales of Meter Specifications.....	29.30	
Sales of Hydrant and Valve Specifications.....	3.10	
Sales of Manuals.....	410.00	
Royalties on Manual Sales (to 6/30/28).....	281.50	
Interest on Deposits.....	195.08	
Interest on Investments.....	842.01	\$51,144.33
Expenditure:		
Convention Expense.....	\$1,871.93	
Office Expense.....	2,107.17	
Committee Expense.....	4,293.13	

STATEMENT OF FINANCIAL CONDITION

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Section and Division Expense.....	2,690.40	
Insurance.....	57.00	
Office of Secretary.....	13,794.26	
Salary of Editor and Assistants.....	3,000.00	
Printing JOURNAL.....	19,823.68*	
Contingencies.....	60.00	
Rent of Office.....	1,421.25	
Manuals, Purchases.....	345.00	
Depreciation, Office Equipment.....	143.83	
Reprints.....	257.75	
Sundry.....	23.17	49,888.57

Income over Expenditure, year ending 12/31/28..... \$1,255.76

* Includes cost of printing 1928 Membership List—\$799.25.

MEMBERSHIP STATEMENT FOR YEAR 1928

	ACTIVE	CORPO- RATE	ASSOCI- ATE	HONOR- ARY	TOTAL
January 1, 1928.....	2,008	199	221	14	2,442
Gains:					
New.....	179	8	16		203
Restored.....	29	3	4		36
	2,216	210	241	14	2,681
Losses:					
Resignations.....	63	8	15		86
	2,153	202	226	14	2,595
Deaths.....	13				13
	2,140	202	226	14	2,582
Dropped for non-payment of dues 12/31/28.....	115	4	7		126
Total December 31, 1928.....	2,025	198	219	14	2,456
Total January 1, 1928.....	2,008	199	221	14	2,442
Gain or Loss in 1928.....	17	-1	-2		14

STATEMENT OF FINANCIAL CONDITION

Gain in year 1928	14
Gain in year 1927	39
Gain in year 1926	187
Gain in year 1925	57
Gain in year ending 3/31/25	222 (fiscal year)
Gain in year ending 3/31/24	224 (fiscal year)
New Members Received During Year 1928	203
New Members Received During Year 1927	284
New Members Received During Year 1926	329
New Members Received During Year 1925	277
New Members Received During Year ending 3/31/25	358 (fiscal year)
New Members Received During Year ending 3/31/24	363 (fiscal year)

Includes cost of printing 1928 Membership List—\$700.25

MEMBERSHIP STATEMENT FOR YEAR 1928

ACTIVE	CONGREGATE	ASSOCIATE	HOUSING	TOTAL
2,008	199	251	14	2,442
179	8	16		203
20	3	4		27
2,210	210	241	14	2,681
25	8	14		47
2,183	202	228	14	2,507
18				18
2,140	202	228	14	2,504
115	4	7		126
2,025	198	219	14	2,436
2,008	199	221	14	2,442
17	-1			16

REPORT OF TREASURER, YEAR ENDING DECEMBER 31, 1928

As Treasurer of the American Water Works Association, I submit my report of the receipts and disbursements from May 1 to December 31, 1928, as follows:

GENERAL FUND

Balance on Deposit, as per report May 1, 1928..... \$15,800.15

Receipts:

From Secretary (Deposited in The Farmers Loan & Trust Company, New York City):

May.....	\$3,513.97
June.....	2,284.84
July.....	1,996.61
August.....	2,011.68
September.....	2,411.11
October.....	2,034.88
November.....	2,369.64
December.....	3,190.88

Total Received from Secretary..... \$19,843.61

From Interest on Daily Bank Balances:

May.....	\$18.79	
June.....	26.31	
July.....	19.95	
August.....	10.21	
September.....	7.43	
October.....	14.69	
November.....	11.33	
December.....	9.80	118.51

From proceeds of investments sold or matured: October 2, 1928, Trade Acceptance bought from The Farmers Loan & Trust Company, July 2, 1928, Matured

Amount invested.....	\$6,290.59	
Interest earned.....	59.27	6,349.86

December 11, 1928—Sale of \$2,000

Corporate Stock of City of New

York @ 98 net..... \$1,960.00

Interest earned..... 89.11 2,049.11

Total Receipts..... 28,361.09

\$44,161.24

Disbursements:

Checks drawn on The Farmers Loan & Trust
Company:

May.....	\$5,486.72	
June.....	1,599.21	
July.....	5,185.54	
August.....	3,558.76	
September.....	3,713.94	
October.....	3,728.29	
November.....	4,398.57	
December.....	5,388.68	\$33,060.01

Debits by Farmers Loan & Trust Company:

For Foreign Exchange..... \$0.75

For Investments:

July 10—Bankers Acceptance, due Oct. 2, 1928.....	\$6,290.59	
July 16—2 Bonds, Alabama Power (\$1,932.50—Accrued Int. \$10.00).....	1,942.50	8,233.09

For Uncollectible Checks..... 12.00 8,245.84

Total Withdrawals..... \$41,305.85Balance on Deposit, December 31, 1928 in The
Farmers Loan & Trust Company.....

2,855.39

\$44,161.24

ELECTROLYSIS FUND

Balance in Farmers Loan & Trust Company,

New York City, May 1 to December 31, 1928.....

\$894.14

(No additions to or deductions from this Fund)

INVESTMENTS IN THE PERMANENT FUND OF THE A. W. W. A. AS OF
DECEMBER 31, 1928

DESCRIPTION OF BONDS	RATE OF INTEREST	COST	INTEREST DUE	DATE OF MATURITY
	<i>per cent</i>			
4—\$1000 Dominion of Canada, Nos. N23795, N24693, N24694, N24460.....	5	\$4,000.00	April October	4/ 1/1931
2—\$1000 U. S. Liberty 4th, Nos. AO1219871, AO1219870.....	4½	2,000.00	April 15 October 15	10/15/1938
3—\$1000 Prov. Ontario, Nos. AC11128, AC11129, AC11130.....	5	3,105.00	April 1 October 1	10/ 1/1942
1—\$1000 Prov. British Columbia, No. EU2552.....	4½	1,000.00	July 15 January 15	1/15/1951
2—\$1000 Alabama Power, Nos. 20906, 20907.....	4½	1,932.50	June 1 December 1	12/ 1/1967
2—\$1000 U. S. Cert. Indebtedness.....	4½	2,000.00	June 15 December 15	6/15/1929

Total amount of bonds..... \$14,037.50

To which is added the following certificates of deposit in the Second National Bank, Erie, Pa. Interest on Permanent Fund:

1—Certificate of Deposit—April 30, 1928, 3%.....	\$260.00	
1—Certificate of Deposit—October 10, 1928, 3%.....	36.25	
1—Certificate of Deposit—December 12, 1928, 3%.....	307.38	603.63

Total permanent fund as of December 31, 1928.... \$14,641.13

GENERAL FUND

Reconciliation of Bank Balance in Farmers Loan & Trust Company with Treasurer of the American Water Works Association.

Balance in Treasury as per Treasurer's Report December 31, 1928... \$2,855.39

Checks Outstanding:

No. 3400.....	\$3.75
No. 3402.....	53.28
No. 3403.....	3.16
No. 3405.....	5.30
No. 3409.....	1.26

No. 3410.....	6.44	
No. 3421.....	296.40	
No. 3422.....	61.50	
No. 3423.....	133.75	
No. 3424.....	500.00	
No. 3425.....	143.25	
No. 3428.....	250.00	1,458.09
Balance as per Bank Books.....		\$4,313.48

Respectfully submitted,

GEO. C. GENSHEIMER,
Treasurer.

SOCIETY AFFAIRS

THE ANNUAL CONVENTION

The forty-ninth annual convention of the American Water Works Association met at the Hotel Royal York, Toronto, Ontario, Canada, on June 24 to 28, 1929. The attendance was about 1,200.

The outstanding events of the convention were the unanimous adoption of the new constitution and by-laws and the formation of the Division of Finance and Accounting.

The Plant Management and Operation Division held its first session at 2.30 p.m., Monday, June 24, with Harry F. Huy in the chair. The feature of this session was a paper by J. Walter Ackerman on operating practice.

H. Gordon Calder, of the Federal Water Service Corporation, spoke on the proposed new section of Accounting and Finance.

The committees on Water Works Practice and on Standard Methods of Water Analysis held informal meetings.

The opening exercises of the convention were held in the Concert Hall of the Hotel Royal York, on Monday evening at 9.30. President Brush, after declaring the convention officially opened, introduced Mayor Samuel McBride, of Toronto, who welcomed the Association to the City.

Dancing and refreshments followed.

General Sessions

Tuesday, June 25, Morning. In opening the first business session of the convention, President Brush read a letter from Mrs. Charlotte Diven, widow of John M. Diven, in which she presented to the Association a gavel which had been used by President Benzenberg in 1892.

Mr. Brush then read his address. He stressed the work accomplished during the year, particularly the formulation of the new constitution and by-laws for the Association. The work of the Standardization Council under George W. Fuller, he said, had culminated in the Manual of Water Works Practice. The work of this Council, now completed as far as it was concerned, would be carried

on by the new and important committee of Water Works Practice, under the chairmanship of Malcolm Pirnie. The Manual, he hoped, would at some future time be thoroughly revised and improved.

The relations with the water works manufacturers had been changed by the assumption by the Association of the convention entertainment, and the fixing of a set sum, as the manufacturers' share in such entertainment. This departure had been greatly aided by the uniform charge of five dollars to all who attended the convention. While this year the membership had not greatly increased, it was hoped that the work of the new special committee on membership headed by Franklin Henshaw, Superintendent of the Scarsdale, N. Y., Water Department, would have excellent results in the future.

One outstanding accomplishment, Mr. Brush said, had been the admission of the Southeastern Water and Light Association as a section of the Association. He believed that it would be a great advantage if all interested in the water works field would come into one strong organization.

A matter which the Association had not done much to advance was that of salaries of water works operators. He pointed out that it would be impossible to obtain the services of the men needed until the water works were prepared to pay the market prices of wages required. He referred to the desirability, perhaps, of licensing all operators. He believed this matter should be taken up by the Association.

Another advance step was the employment of Mr. Ruggles as Assistant to the Secretary.

Mr. Brush thanked all the members for the splendid support they had given him and his administration during the year.

The President then asked Secretary Little to read the list of officers, who, with no opposition, were declared elected. These follow: President, Jack J. Hinman, Jr.; Vice-President, George H. Fenkell; Treasurer, George C. Gensheimer; Trustees: District No. 3, J. Walter Ackerman; District No. 5, A. F. Porzelius; District No. 7, W. T. Mayo.

The President called upon Mr. Hinman, who made a short address of thanks.

This was followed in order by the Secretary's and the Treasurer's reports, both read by Secretary Little.

In this connection, it was announced with regret that Treasurer

Gensheimer was dangerously ill with pneumonia at his home in Erie, Pa. A motion was made by Theodore A. Leisen, that the Association send its sympathy and hope for a speedy recovery to Mr. Gensheimer. Motion carried.

The Budget, as presented by the Budget Committee, was adopted.

The report of the Committee on Water Works Practice was read by its chairman, Malcolm Pirnie.

At the conclusion of the report Stephen H. Taylor moved that the report be received and that its recommendations be adopted. Carried.

Mr. Brush read the report of the Diven Memorial Medal Committee and presented the medal for the man who had done most for the Association during the year to James E. Gibson.

The Chair then announced the consideration of the proposed new constitution and by-laws of the association, and called upon R. L. Dobbin, Chairman of the Constitution Committee, for the report.

Mr. Dobbin said that the original committee on the revision of the constitution in 1927 consisted of Messrs. Fuller, Deberard, Brush, Fenkell and President Gibson. The new committee at San Francisco was composed of Messrs. Fenkell, Deberard, Cramer, Robert S. Weston, Pracy, O'Brien and Dobbin, as chairman; with Wm. W. Brush, the President, Beckman C. Little, Secretary and Abel Wolman, Editor of the Journal, as ex-officio members. The Committee had consulted counsel as to the legal phases of the constitution, had held many meetings and conducted much correspondence.

Mr. Brush spoke of the excellent work the committee had done on the revision of the constitution and called upon Mr. Gibson, as the President in whose term the revision had been started, to move its adoption. The adoption was seconded by Mr. Leisen and President-elect Hinman also spoke in favor of its adoption. The motion was unanimously carried without discussion.

A vote of thanks was given the committee for its work on the new constitution.

Tuesday, June 25, Afternoon. The afternoon session was composed of a symposium on pumping station practice. The papers were read as follows:

"Selection of Equipment for Clove Pumping Station of Staten Island System," by William Flannery. "Selection of Pumping Station Equipment," by A. P. Pigman. "Equipment for Electrically

Driven Pumping Stations," by R. L. Baldwin. "Pump Discharge Headers and Pump Piping for Water Works Stations," by F. G. Cunningham. "Comparative Data on Steam and Electrical Pumping Stations," by John F. Laboon.

There was considerable discussion of these papers by Messrs. Morris, Gibson, Wilson, Burdick, Lanpher, Maury, Dixon, Hutson, Laboon, Hall, Day, and others.

Boiler Feed Water Studies

Two sessions of Committee No. 19, on Boiler Feed Water Studies, were held on June 25, with Sheppard T. Powell, Chairman, in the chair. One session was at 9 a.m. and the other at 2 p.m. The papers considered and discussed were:

"Recent Developments in Boiler Operation and Their Influence on Feedwater Treatment," by Sheppard T. Powell.¹ "Deaeration of Boiler Feedwater," by J. R. McDermet.² "The Dissociation of Water in Steel Tubes at High Temperatures and Pressures," by C. H. Fellows.³ "Calculation of Chemicals for Water Softening," by A. M. Buswell. "The Prevention of Pitting in Locomotive Boilers by Exclusion of Dissolved Oxygen from the Feedwater," by C. H. Koyle.⁴ Discussion by R. E. Coughlan and F. N. Speller. "Railway Water Treatment Progress and Research Requirements," by R. C. Bardwell. "Hydrogen Ion and Conductivity Measurement," by C. Z. Rosecrans.

The ladies were given a bus tour of the city and tea at the Royal Canadian Yacht Club at 2 p.m., and a card party in the evening.

At 7.30 the annual dinner of the Purification Division was held. This was attended by a large number of ladies in addition to the usual male attendance.

General Sessions

Wednesday, June 26, Morning. The first paper of the session was by Nicholas S. Hill, Jr.,⁵ on the subject of "Ethics for Engineering Services."

¹ JOURNAL, August, 1929, page 1063.

² JOURNAL, October, 1929, page 1339.

³ JOURNAL, October, 1929, page 1373.

⁴ JOURNAL, August, 1929, page 1013.

⁵ JOURNAL, September, 1929, page 1170.

A paper was read by H. Y. Carson on the "Durability of Distribution Systems."

In discussing the paper, Mr. Brush referred to the question as to whether it was more feasible to protect the metal from corrosion by means of coatings or linings, or to change the type of water.

Franklyn C. Hopkins raised the question as to whether corrosion really lessens the life of pipe. He called attention to the fact that the space occupied by the tubercles was six or seven times as thick as the iron removed, so that it would take years to penetrate the iron. If anything, the action of the tubercles would tend to increase the strength of the pipe, while reducing its carrying capacity.

Allen Hazen pointed out that corrosion works both ways. Some of the tubercles pass into the water and affect its quality. Double dipping is a good method of reducing corrosion, by lessening tendency to penetrate the lining.

George H. Fenkell said that in the old days few cities were equipped with methods of treating water supplies. The helpful method is to treat the water. This is much more easily accomplished than formerly. The question of the treatment of water for steam boilers is a very live one, and very careful consideration has been given to it.

Others discussing the paper were Messrs. Crowley, McCallum, etc.

The final paper of this session was by J. Clark Keith, on "Operation of Large Capacity Filter Plants."

In discussing this paper Paul Hansen spoke of difficulties experienced through frazile ice in the clogging of intakes under certain current conditions in lake supplies. He also referred to the troubles through the formation of mud balls in filters and the remedy.

Wednesday, June 26, Afternoon. Papers on the subject of chlorine treatment occupied most of the Wednesday afternoon session. The first of these was "Field Practice in Chlorination of New and Old Water Mains," by Joseph S. Strohmeyer. This was followed by a paper on "The Chlorine Institute Standard Valve for Chlorine Containers," by R. T. Baldwin.⁶ This paper was illustrated by lantern slides. A third paper on the subject was "Water-Borne Epidemics on Ships with Reference to the Outbreak on the Lake Gaither," by I. W. Mendelsohn.

⁶JOURNAL, June, 1929, page 815.

There was much discussion of the topic of water treatment by chlorine in its various phases at this session. An important paper also read at this session was on "Cobble Mountain Dam of the Springfield, Mass., Water Works," by Allen Hazen.⁷

Wednesday, June 26, Evening. As there was only a short time in the evening before the smoker, only two papers were read. These related to the water supply of the convention city. The first was by R. C. Harris on "The Toronto Water Works System." He was followed by William Gore who spoke on "The New Filtration Plant and Other Extensions of the Toronto Water Works."

At 9.30 an excellently arranged smoker was given.

The ladies of the convention were given a shopping tour through the store of T. Eaton Company, Ltd., with tea by compliments of the company in the Georgian Room of the establishment. There was a theatre party in the evening.

Plant Management and Operation Division

Thursday, June 27, Morning. The morning session on Thursday opened with a business session of the Plant Management and Operation Division. The officers elected were Chairman, A. U. Sander-son; Vice-Chairman, James Sheahan; Trustee, Patrick Gear.

Three papers were read. The first was by Scotland G. Highland⁸ on "Pure Stream Movement Will Accomplish Its Purpose."

The second paper was on "Management and Operation of a Canadian Water Works System," by W. E. MacDonald.⁹

The final paper of the session was on "The Two-Main Systems of Water Distribution," by J. B. Eddy.

Thursday, June 27, Afternoon. The Thursday afternoon session was devoted to a symposium on large sized pipe. This was composed of a number of papers on the subject of steel and wrought iron pipe of large diameter. Electric welding came in for a large share of attention.

The first paper was on "Welded Steel Pipe at Springfield, Mass.," by Allen Hazen. Three systems of welding steel pipe were then described by Samuel Martin, Jr.,¹⁰ J. F. Lincoln and E. F. Shanor.

Other discussions on the subject were by F. H. Stephenson, Wil-

⁷ JOURNAL, July, 1929, page 879.

⁸ JOURNAL, August, 1929, page 1081.

⁹ JOURNAL, October, 1929, page 1265.

¹⁰ JOURNAL, September, 1929, page 1117.

liam Flannery, F. G. Cunningham, John F. Skinner, A. O. Doane and C. V. Witt.

R. H. Keays¹¹ read a short paper on European pipe practice.

Finance and Accounting Division Formed

At 10.30 a.m., Wednesday, June 26, a meeting was called in Room No. 1 to form a "Finance and Accounting Division." A group of members interested in this important phase of water works practice assembled. The meeting was called to order by N. Gordon Calder, Assistant Comptroller, Federal Water Service Corporation, New York City.

President-Elect Hinman, of the Association, said that he voiced the sentiments of the Board of Directors of the Association in speaking heartily in favor of forming this new division. Mr. Calder then read the petition to the Executive Committee asking permission to form the division and asked every member present to sign the petition.

Mr. Calder then read the proposed constitution and by-laws of the division, which, after some changes, were unanimously adopted.

The chair asked that the new by-laws be suspended for the time, so that the officers for this year could be elected at once. This was done and the election resulted in the following officers being chosen:

Chairman, H. Gordon Calder; Vice-Chairman, Mr. Smith. Directors, Franklyn C. Hopkins and Abraham M. Bowman.

Mr. Ormerod read a paper on the methods of income tax accounting. A discussion on the income tax situation in connection with water works employees followed. Those taking part in this were Messrs. Ruggles, Grobbel, Chambers, Hopkins and Cramer.

The question was raised as to whether ladies could become members, and the chair replied that there was no reason why they should not. Mr. Cramer said the ladies would be interested, and Mr. Ruggles announced there were now three women members of the Association.

Robert H. Lockwood suggested that a membership committee should be included, which should circularize all of the water works—both municipal and private—as to membership in the division. He suggested that in this way the membership of the Association as well as the division would be increased.

The chair said that the committees, as at present planned, would be

¹¹ JOURNAL, June, 1929, page 820.

on membership; on classification of accounts; on taxes and on methods and general financial problems. There was a lengthy discussion on methods of accounting. Mr. Michaels thought the committee on classification of accounts should do some speedy work on this subject. Others spoke on the work of the committee, including Messrs. E. W. Agar, Morris, Calder, Hopkins and Ruggles.

General Session

Friday, June 28, Morning. The first paper was read by C. A. Holmquist on "New Developments in the Safeguarding of Cross Connections in New York State." The second paper was "Mechanical Developments in Water Treatment Practice," by C. T. Leander. The third paper was on "Steel Tanks for Water Works Systems" by George T. Horton.¹² The final paper of the session was by J. A. McGarigle on "Methods of Water Softening and Filtration."

Plant Management and Operation Division and Superintendents Round Table Discussion

Friday, June 28, Afternoon. At the final session on Friday afternoon, a paper was read by William W. Brush on "Effect of Rigid Jointing Material on the Strength of Pipe Bells," and by R. W. Reynolds on "Cement Lining Small Iron Pipe—A Method Suitable for Small Utilities." There was considerable discussion on the papers and on general water works subjects. At the end of the session the convention adjourned.

Water Purification Division

This division of the Association held three sessions in all—one on Wednesday morning, one Thursday morning, and one Thursday afternoon. The election of officers resulted as follows: Chairman, Frank E. Hale; Vice-Chairman, John R. Baylis; Secretary (re-elected), Harry E. Jordan; Directors, W. F. Langelier, Charles H. Spaulding and Rudolph E. Thompson.

The Purification Division activities during the Convention may be summarized as follows:

1. *June 25, 2 p.m.* Inspection of the Toronto Purification Plant.
2. *June 25, 7 p.m.* Division Dinner. 169 present. In the absence of Chairman, Harry E. Jordan presided. Entertainment was furnished by Wm. J. Orchard and R. L. Dobbin.

¹²JOURNAL, August, 1929, page 1005.

3. June 26, 9 a.m. C. P. Hoover presiding. Papers presented as listed in program:

"Values in Natural and Artificial Purification with Reference to the Sangamon River at Springfield, Ill." By Charles H. Spaulding.

"The Deposition of Manganese Dioxide in the Aqueduct of the Catskill Water Supply." By Frank E. Hale.

"Micro-organisms in the Lake Michigan Water and Their Effect on Filtration." By John R. Baylis and H. H. Gerstein.

"Innovations in the Treatment of Water in the Province of Ontario." By A. V. DeLaporte.

"Some Unusual Features in Design of the New Water Purification Plant at Niagara Falls." By F. A. Dallyn.

The Chairman appointed a committee with Edward Bartow, Chairman, to nominate Division officers of the ensuing year.

4. June 27, 9 a.m. C. P. Hoover presiding. Papers presented as listed in program:

"The Relations of Direct B. Coli and B. Aerogenes Counts, Obtained on Cyanide-Citrate Agar, to Sources of Pollution." By Fred O. Tonney and R. E. Noble.

"Lactose Fermenting Bacilli Growing on Leather Washers." By Frank E. Greer and Laura C. Kells.

"Ultra-Microscopic Studies of Colloids in Water." By C. H. Christman.¹³

"The Use of Activated Carbon in Removing Taste Producing Substances from Water." By John R. Baylis.¹⁴

5. June 27, 2 p.m. C. P. Hoover presiding. Papers presented as listed in program:

"Trends in Municipal Zeolite Water Softening." By W. J. Hughes and H. B. Crane.

"Reduction of Carbonate Hardness by Lime Softening to Theoretical Limit." By Charles P. Hoover and James Montgomery.¹⁵

"Zeolite Softening Plant Operating Experiences." By D. E. Davis and J. T. Campbell.

"Operating Experiences with a New Water Softening Plant at Marion, Ohio." By Martin E. Flentje and Charles Whysall.

¹³ JOURNAL, August, 1929, page 1076.

¹⁴ JOURNAL, June, 1929, page 787.

¹⁵ JOURNAL, September, 1929, page 1218.

ABSTRACTS OF WATER WORKS LITERATURE¹

FRANK HANNAN

Key: American Journal of Public Health, 12: 1, 16, January, 1922. The figure 12 refers to the volume, 1 to the number of the issue, and 16 to the page of the Journal.

Results Obtained in Phenolic Wastes Disposal under the Ohio River Basin Interstate Stream Conservation Agreement. F. H. WARING. American Journal of Public Health, 19: 7, 758-770, July, 1929. Complete review of the success of the coöperative endeavor of the departments of health of the States in the Ohio River Drainage Basin. The difficulty from phenolic wastes brought forcibly to the attention of the country the national survey made by the Federal Government in 1924, although difficulties were experienced at Cincinnati in 1917, and at Morgantown, W. Va., and other Ohio River cities in 1918. Due to the fact that coke plants on this interstate stream might be located in one state and cause difficulties in water supplies of other states, it was necessary for the states to act jointly and the Ohio River Basin Interstate Stream Conservation agreement was formulated. Conferences were held between representatives of the coke plants, state officials, and water works authorities and a program for the prevention of pollution by phenolic wastes was agreed upon. As a result of this coöperative endeavor, phenolic wastes have been excluded from the streams of Pennsylvania through the utilization of the recirculation systems whereby these wastes are evaporated with the quenching water. At other points, phenol recovery plants have been constructed, in which the phenols are absorbed from the wastes by benzol scrubbers. Tabulated data are given relative to the by-product coke plants in the States of Ohio, Kentucky, and West Virginia. In a discussion of this paper, W. L. STEVENSON, of Pennsylvania, C. A. HOLMQUIST, of New York, and E. S. TISDALE, of West Virginia, review in greater detail the activities in these three states in the prevention of stream pollution by phenolic wastes.—C. R. Cox.

System of Meter Changing and Setting Used in Lima, Ohio. American City, 41: 1, 95-97, July, 1919. Detailed description of the office and plant procedures followed by the water department of the city of Lima, Ohio, in the maintenance of meters. Approximately one-third of the total revenue of the water

¹ Vacancies on the abstracting staff occur from time to time. Members desirous of coöperating in this work are earnestly requested to communicate with the chief abstractor, Frank Hannan, 285 Willow Avenue, Toronto 8, Ontario, Canada.

department is derived from 135 water consumers made up of hotels, manufacturing plants, large apartments, etc. In all, however, there are over 10,000 meters in use; so it is very important that the meters on the large services be carefully maintained.—C. R. Cox.

The Granville Dam of the Westfield, Mass., Water-Supply. C. A. FARWELL. *The American City*, 41: 1, 124-128, July, 1929. The Granville dam of the City of Westfield, Mass. is located on Little River. It is a large earthen dam with a maximum height at the center of about 80 feet, and slopes of 3 to 1 on the upstream side, and of 2 to 1 and $2\frac{1}{2}$ to 1 on the downstream side. Stone facing is used on the upstream side and the downstream toe is provided with a stone embankment. The earth used in the dam was such that a core wall was not needed. The spillway is located at the southern end of the dam on the right bank. The crest length is 60 feet, which, with a water depth of 4 feet, provides a capacity of about 2,000 cubic feet per second or 330 cubic feet per second per square mile of watershed. The flow line of the reservoirs is to be stripped of loam through a vertical distance of 12 feet and is to be grubbed of all vegetable matter to a further depth of 18 feet measured vertically. In addition certain swampy areas are to be covered with sand or gravel to suppress aquatic vegetation. The total cost of the project is estimated to be \$630,000, of which \$525,000 is for the contract work described in the article.—C. R. Cox.

A Survey of Water Meter Rates in the United States. Part II. *American City*, 41: 1, 147-150, July, 1929. This is Part II of a lengthy tabulation of water supply statistics published in the *Municipal Index* for 1929. The material cannot be abstracted.—C. R. Cox.

Report of the Water Pollution Research Board (England) for the Year 1927-8. This is the first report of the Board, appointed June 30, 1927, as a part of a comprehensive plan by the Government for dealing with the pollution of rivers and streams. During the first year of its existence the Board arranged for the preparation and publication of monthly summaries of current literature on water supply, sewage, trade waste water, river pollution and related subjects. Plans were made for a general biological and chemical survey of the River Tees, a typically polluted English river, which, starting as an unpolluted stream receives a variety of domestic and industrial effluents and ends in a tidal estuary. A study of the zeolite process of water softening has been arranged for with special reference to the rate and extent of base exchange, wastage of material, possibility of contamination, by silica and alumina, of the softened water, how far the action of exchange is a surface phenomena depending upon the size and texture of the particles of the base exchange materials and the process of regeneration. Preliminary studies of beet sugar factory waste water have been made with reference to decreasing the volume of the waste water to be treated and the purification of the water by biological treatment in a small scale experimental plant at a representative factory. The report of the Director, Water Pollution Research, summarizes the results of this investigation insofar as data have been obtained during one season's operation of the experimental plant.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

The Effects of Stream Pollution on Fishes and their Food. STEPHEN A. FORBES. The Natural History Survey Division, Urbana, Illinois. This article points out that it is impossible to give a categorical answer to the question, "What is the effect of pollution by sewage upon fishes and their food?" for the reason that the elements of the problem are numerous and variable. A discussion of the various elements is given.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Resolve Providing for an Investigation by the Department of Public Health Relative to the Extension of the Metropolitan Sewerage System in the Neponset Valley and the Cost Thereof. Massachusetts House Report No. 212, December 1, 1926. The report describes the Neponset River watershed in some detail, and outlines the amount and nature of the present pollution thereto. The quality of the water in this river has been slowly deteriorating for thirty years, and the Department expresses the opinion that it would not be advisable to add domestic sewage from the Metropolitan district to the river, but rather reduce the present pollution. The report advises a connection to the South Metropolitan system for the disposal of domestic sewage from the towns enumerated above, and the closing pages give in considerable detail the plans and cost for such an arrangement.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Der Ruhrverband. (2nd Edition, July, 1928. Pub. by Carl Heymanns, Berlin W. 8.) Dept of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 2, December, 1928. "This pamphlet gives an account of the more recent activities of the Ruhrverband. A description is first given of the area under the jurisdiction of the Board and an indication given of the distribution of population and of the centres of industrial development. A table showing the amount of water supplied annually by a number of water works is given. Then follows an account of the history of the Ruhrverband and a description of its management. The final section of the pamphlet deals with the technical side of the work of the Union, with particular reference to the recent developments made in the area in sewage purification methods."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Old and New Methods for the Disposal and Utilization of Dairy Effluents. (J. Bettels, Gesundheits-Ingenieur, 1928, 51,539.) Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 2, C-9, December, 1928. "At dairies, the effluent consists mainly of washings from milk cans and condensing water. It is therefore very dilute and can be discharged directly into any stream affording a dilution of 1:100 or 150. The effluent may also be successfully treated in percolating filters or contact beds or by land irrigation, provided it is discharged in a fresh condition and that the lactic or butyric acid fermentation has not supervened. Pre-treatment in settling tanks provided with scum boards to retain the fats is advantageous, and any tendency to the production of odours can be counteracted by the use of chlorine compounds. The effluent may also be con-

veniently discharged into fish ponds."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Progress of Surface Water Treatment. HAUPT. Vom Wasser. Yearbook for sanitary chemists and engineers. Printed by: Chemie, G. m. d. H. Berlin W. 10, 1928. Progress of surface water treatment. Review of surface water treatment in this country and abroad.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Chlorine Consumption in Water. BESEMAN. Vom Wasser. Yearbook for sanitary chemists and engineers. Printed by: Chemie, G. m. d. H. Berlin W. 10, 1928. The conclusions reached after an extensive study of chlorinated organic substances in water are briefly: (1) Chlorine consumption in water is caused by organic and inorganic substances; (2) pH values do not affect chlorine consumption; (3) light intensity plays a rôle. Best is to add chlorine in the dark; (4) it is immaterial whether a chlorine solution or a hypochlorite solution is used; (5) differences in temperature affect chlorine absorption, so that in practice the chlorine dosage should be changed with the temperature of water; (6) a detention period of five minutes is sufficient since practically no difference was observed between five and sixty minutes contact periods; (7) residual chlorine requires more chlorine and it is recommended to use the Olszewski method—just sufficient chlorine—in practice.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

A Modern Rapid Filter for Water. G. BOLLMAN. Vom Wasser. Yearbook for sanitary chemists and engineers. Printed by: Chemie, G. m. d. H. Berlin W. 10, 1928. According to the author, the Bollman rapid filter "approaches the ideal," because it gives dependable results, good purification and washing, and low operation cost. The article is illustrated with a number of drawings.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Evolution of B. Coll in Drinking Water. JAN SMIT. Vom Wasser. Yearbook for sanitary chemists and engineers. Printed by: Chemie, G. m. d. H. Berlin W. 10, 1928. The article contends to answer the following three questions: (1) Is it possible to describe the "typical colon-bacillus" and its importance for the hygienic danger when present in water; (2) how can we designate the danger if only atypical forms are encountered, as is often the case in practically unpolluted waters; (3) in what quantity of water should B. coli be absent, provided all other standards are met. The article is written with pollution by cold blooded animals (frogs, etc.) in mind. The pollution organisms are destroyed in stages and instead of using the B. coli numbers as an index the "age of the infection" should be used as indicated by the fermentation methods worked out by Eijkman, e.g., glucose-peptone media incubated at 37°C.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Chlorination of Water Supplies. J. M. MATHEW. Proc. of the First Commonwealth Conference on Public Health Engineering, Dept. of Health, Melbourne, Australia. This is a comprehensive review of the chlorination of

water supplies in which experiences in Australia, England and America are considered.—A. W. Blohm. (*Courtesy U. S. P. H. Absts.*)

Miniature Filter puts Across Water Vote. E. G. WILSON. *Water Works Engineering*, 82: 1, 11, January 2, 1929. Detailed and illustrated description of construction of small mixing and coagulating chambers and a glass-sided rapid sand filter unit installed and actually operated in a prominent store window in Ottawa, Canada, in order to inform the public just prior to an election to authorize funds for a new water filtration plant.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

The Water Supply of the Ruhr District. KARL IMHOFF. Reprint from the annual report of the Rhein-Westfalia Industrial Territory for the year 1928. The total water demand in the Ruhr Industrial district is 600,000,000 cubic meters per year. Five hundred million of this demand is taken from the Ruhr valley, 70 million from the Rhein valley and 30 million from the Lippe valley. The Ruhr river water is filtered naturally through the gravel and sand stratum in which the river bed lies, and is withdrawn through filter galleries. The water is specially suited to the industrial demand as it is soft. The overhead cost is low because of the fact that the Ruhr parallels the industrial territory, thus leading to a low average delivery radius. In general, while the problem of water supply in the Ruhr district is more difficult than elsewhere in Germany it has been possible through the formation of the Ruhr federation and the resultant economies, to solve the problem satisfactorily at no greater cost than obtains elsewhere in Germany.—A. W. Blohm. (*Courtesy U. S. P. G. Eng. Absts.*)

When the Water Works is not Liable. LEO T. PARKER. *Water Works Engineering*, 82: 2, 81, January 16, 1929. The author points out wherein a municipality is liable for negligent acts on the part of its employees and wherein it is not, and gives a number of interesting decisions as illustrations. A municipality is not liable for negligent acts of its employees performed in its governmental, legislative or discretionary powers but is liable in damages for negligent acts performed by its employees in the exercise of power and privileges conferred upon it for its private gain or advantage, usually termed proprietary or ministerial powers.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Compact Layout, with Efficiency, Attained in Purification Plant. JOHN H. KUESTER. *Water Works Engineering*, 82: 1, 30, January 2, 1929. This article is a brief concise description of the new water purification plant at Menasha, Wisconsin. The water supply flows by gravity from the lake to a cistern where it is pumped by a low head electrical driven centrifugal pump to the aerator which consists of 32 spray nozzles arranged so that a battery of 12 can be shut off during normal operation. The settling basin consists of a reinforced waterproofed concrete tank 18 feet deep by 80 feet square, divided in the center to make two basins. Part of the roof of the settling basin constitutes the floor of the aerator tank, dimensions of which are 30 feet by 34 feet

and 4 feet deep. There are four one million gallon capacity filter units equipped with hydraulic control valves and rate controllers. The rate controllers are arranged so that they will automatically close when the clear well is full. The clear well is directly below the filters and is 40 feet wide, 100 feet long and 8 feet deep, divided by a division wall. In one end of the division wall there is an opening 4 feet by 7 feet through which all the water must pass from one half to the other. One reason for the small opening is to create sufficient water velocity to prevent freezing. Large industrial consumption is the reason given why a city of 8,500 population requires a four million gallon filter plant.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Not All Wells and Springs Deliver Germ-Free Waters. JAMES L. BARRON. *Water Works Engineering*, 81: 20, 1438, September 26, 1928. A case is cited when coal miners attempted to get rid of acid mine wastes by drilling some 1,000 feet into a vein of fresh water which forms the water supply of a number of cities in southeastern Kansas. The drilling was stopped at 800 feet by a court order and the injunction made permanent. The article continues with a very sensible discussion of well construction and protection of all types.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

The Question of the Volumetric Determination of Sulphate in Water by the Barium Chromate Method. (G. NACHTIGALL and F. RAEDER. *Arch. Hygiene* 1928, 100, 31.) *Chem. Zentr.* 1928, (ii) 99, 1370. Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 212, A-23, December, 1928. In the analytical determination of sulphate in water by the barium chromate method, interference is caused by the presence of organic substances. This can be avoided by previous treatment of the water with hydrogen peroxide.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

A Simple Apparatus for the Sterilization of Water by Caporit and by Chlorine. (C. P. Mom, Director of Testing Station for Water Purification at Manggar, Pamphlet.) Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 2, A-27, December, 1928. During the last few years a considerable number of water works and bathing pools have been installed in Dutch East Indies and in many cases the water is sterilized by means of chlorine or caporit. A description is given of an apparatus, which consists of a concrete container with a calibrated discharge tube. With this apparatus an accurate control of the dose of liquid chlorine or caporit is possible. Caporit is used in the smaller plants, and liquid chlorine in the larger water works and bathing pools.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Experience in the Chlorination of Surface Water at Low Temperatures. G. NACHTIGALL. *Arch. Hygiene*, 1928, 100, 25). *Chem. Zentr.* 1928 (ii) 99, 1369. Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 2, A-28, December, 1928. It is not always possible by chlorination of a water, purified by slow sand filtration,

to reduce the bacterial count to less than 10 per cubic centimeter or to ensure the absence of *B. coli* in a litre of water. If sufficient chlorine is added to effect this there is always the possibility of introducing a chlorine taste. By cautious chlorination, however, it should be possible to reduce the bacterial count below 100 per cubic centimeter.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Some Useful Design Data on Rapid Sand Filtration Plants. T. C. HERSEY. *Water Works Engineering*, 82: 3, 169, January 30, 1929. Author discusses fully the determination of sand bed area, number of filter units, relationship between length and width, standardized parts, underdrain systems, gravel and sand beds, wash water troughs and mechanical equipment.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

An Additional Study on the Chlorination of Running Water. JOKAI IGUCHI and TSUNE OUCHI. *Jour. of the Public Health Association of Japan*, 4: 12, 1, December, 1928. Running water in a ditch was highly polluted by organic wastes and had been the cause of numerous enteric outbreaks. Disinfection by the use of bleaching powder fed from a solution barrel was tried and later an emulsion of bleaching powder and very dilute hydrochloric acid was introduced at the same point. With bleaching powder alone a reduction in bacteria of about 80 per cent was obtained. The introduction of acid was followed by a residual bacteria count of less than 50 per cent of that found after use of chlorine alone. The authors conclude that the dilute hydrochloric acid-bleaching powder emulsion greatly increases the efficiency of the chlorine and that chlorine odor is greatly diminished.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Water Works Progress in Modern China. Reprinted from *Far Eastern Review in Water Works Engineering*, 82: 1, 17, January 2, 1929. A modern rapid sand water filtration plant of 20 m.g.d. capacity was developed to serve Chapei, adjacent to the Shanghai International Settlement, whose population doubled within a few years. Governmental and financial obstacles delayed needed expansion, but plant built by the business interests was placed in operation in 1928. Unusual features include pump house founded on soft river bottom and designed to care for varying river stages; the use of typical Chinese architecture for all buildings; the location of the clear well under the whole area of the coagulation basin and a water tank designed as a Chinese pagoda to equalize pressure in the water mains.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

The Kaplan-Reger Process for Purifying Mine Water. DAVID B. REGER. Memorandum for the Press, West Virginia Geological Survey. The process generally speaking consists in adding to the sulphate waters from coal mines a complex organo-metallic compound, which combines with the chemical compounds of the water and forms a blue pigment to be known as Monongahela-Blue, and at the same time removes the acid. In general the use of the process will depend on whether water purification alone is desired or whether the re-

covery of chemical by-products is the main consideration. The pigment removed has a market value to date approximately 100 per cent greater than the re-agent added. In the Kaplan-Reger process the chemicals combine completely with the chemicals in the water to form an insoluble, marketable product leaving the water practically free from acid and mineral substances.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Waukegan Leads the Way in Water Supply. LOUIS J. YAGER. *Illinois Municipal Review*, 8: 2, 76, March, 1929. Waukegan secures the water for its new plant from a point 4,000 feet out in Lake Michigan at a depth of 27 feet. The plant is designed on the duplex plan. The raw water is discharged through two parallel Venturi meters into cast iron grit chambers from which it flows into the primary aeration channels. Aeration is obtained by a new arrangement, the principal advantages of which are; low cost of operation and small space required. Ten filter beds are provided, 5 on each side. Normal capacity of each filter is 1,000,000 gallons per day. A new and novel arrangement of the underdrain pipe system of the author's own design has been installed. Each filter is provided with rate controllers, water sampling device, rate and loss of head gauges. The pipe gallery is constructed on a duplex plan system. Beneath the filters and the pipe gallery floors are situated the clear wells. By means of proper valves one or both clear wells may be discharged into both or each of the storage reservoirs. Two chlorine booths are provided one on each end of the main pipe galleries, each with two chlorine machines. Chlorine is discharged into the outlets of the clear well main. Mixing of the chlorine is accomplished in the secondary aerators. Recording gauges and meters are provided for all steps in the treatment. A well equipped office and laboratory are also provided. The heating plant may be operated on either coal or oil. The plant has a daily capacity of 20,000,000 gallons, and a filtered water storage reservoir of 4,300,000 gallons capacity. The maximum rate of filtration is to be about 15,000,000 gallons. The plant was placed in operation January 9, 1929.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Report on Water Supply at Regina, Sask. ANON. *Canadian Engineer*, 56: 7, 225, February 12, 1929. Data are given from a number of reports on the water supply of Regina, Sask. The present supply, derived from wells and conveyed approximately seven miles through two pipes 10 and 18 inches in diameter to the city, is now yielding the maximum amount of water possible under the present system of development, and possibly the maximum under any system of development. The water is of excellent bacterial quality, but is hard. Work is at present under way on the development of an additional supply of $\frac{3}{4}$ m.g.d. from certain creek beds extending 20 miles in an easterly-southeasterly direction from the city, known as the Mallory Springs supply. This will increase the available supply to about $3\frac{3}{4}$ m.g.d., which was expected to be sufficient for 4 or 5 years. The growth of the city, however, makes it probable that this amount will only be sufficient for two years, and other sources must be investigated immediately. Sources under consideration include the Saskatchewan River, 112 miles distant, the water of which is soft

but not sufficiently clear to use without filtration, and the Carlyle Lakes 115 miles distant, the water of which is considerably harder than the present supply. Long Lake, the nearest large body of water, is not considered a suitable source of supply owing to its high content of non-hardening salts.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Progress in Municipal Engineering. ANDREW L. REID. Surveyor, 74: 1911, 207, September 7, 1928. Water Supply. Many of our earlier ideas regarding water treatment have been changed. Storage to improve the quality of the water is now considered entirely safe from a bacterial standpoint. With the present demand for large quantities of water in a short space of time the gravity filter may be supplemented with a mechanical filter when coagulants or precipitates are used. This combination furnishes both speed and efficiency in water filtration. Although considerable objection to the use of chlorine was made at first its use now is considered a necessity. Furthermore, with the sterilization produced by chlorine, polluted water may be made available for domestic consumption.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Problems of Cholera in China and Japan. YANG TING KUANG. *Jl. Oriental Med.*, 9: 3, September, 1928 (In Japanese. English summary. pp. 29-34.) *Tropical Diseases Bulletin*, 26: 2, 84, February, 1929. "The author considers the serious problems of cholera in China and Japan and makes many suggestions for dealing with them. Among them are (1) an intensive study of endemic areas in the Yangtze Valley; (2) removal of causes—control of waterworks, sterilization of wells, etc. (a beginning has been made by the Shanghai Chinese Health Authorities); (3) mass vaccination and vaccination of each passenger leaving for Japan or Manchuria. As an Appendix the author gives the rules for dealing with cholera in ships, as formulated at the International Sanitary Convention, 1926."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

A Brief Outline of Legislation Governing Town Water Supplies in the State of Victoria. WM. F. NEVILL. *Proc. First Commonwealth Conference on Public Health*, September 19-27, 1927. Service Publication No. 2, Division of Public Health Engineering, Dept. of Health, Commonwealth of Australia. pp. 22-24. This article describes the procedure to be followed in the State of Victoria in establishing local Waterworks Trusts under the Water Acts of the State. The State Rivers and Water Supply Commission is the principal controlling authority and town water supply developments are carried out under its general supervision by a waterworks trust or by a municipal council vested with powers similar to those enjoyed by a trust. Upon approval of the application of the Governor in Council, the duly appointed waterworks trust submits detailed plans and specifications to the State Rivers and Water Supply Commission for examination and approval, after which bids or tenders for the construction are obtained. Contracts for construction are subject to the approval of the Governor in Council. Money required to finance the construction of approved works is advanced by the Governor in Council, as loans on long terms at favorable rates of interest, out of funds provided usually

once in each year by a water supply loans application act. Each year the Waterworks Trust submits an estimate of the annual charges—interest, redemption, depreciation, maintenance and management—and the rating required to meet these obligations for the approval of the Minister of Water Supply, which rating is passed thereafter as a by-law by the local waterworks trust, subject to the approval of the Governor in Council.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Water Works and Sewerage Systems. A. E. BERRY. Canadian Engineer, 56: 7, 223, February 12, 1929. A review of the water works and sewerage system installations and extensions undertaken and proposed in Ontario during the year 1928. More activity has been shown in this field during the past year than in any year since before the war. A marked increase has been noted recently in the use of deep wells as sources of water supply. The water works systems of the province at the end of 1928 comprised a total of 251, of which 47 derived their supply from deep wells, 70 from rivers, 53 from lakes and 38 from springs. The number of filtration plants totalled 48, of which 6 were of the slow sand type, 26 pressure mechanical and 16 gravity mechanical. Chlorination is now almost universal practice, the number of supplies so treated being 114, representing over 75 per cent of the total water supplies for domestic purposes.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Water Supply and Sewerage and Sewage Disposal. ANON. Surveyor, 74: 1911, 206, September 7, 1928. The Minister of Health in the annual report stated the average rainfall for England and Wales was 43.7 inches for the year 1927. While this amount of rainfall was exceeded in some sections it fell considerably below that average in others. Considerable difficulty has been experienced in finding new sources of water supply. In certain areas where the supply is obtained from springs and underground waters, these sources are utilized to their fullest extent. There is at present a growing tendency to resort to the lower course of rivers for water supply. This latter plan has been looked upon quite favorably due to the success of the Metropolitan Water Board in treating water from the River Thames. The difficulties encountered in obtaining fresh sources of supply have brought into prominence the desirability of pooling the water resources of neighboring companies. This plan saves in the duplication of material, and also amalgamates the various supplies under one administration. The consumption of water for domestic purposes has grown considerably in recent years. This is partly due to increased population, but also to changing habits and the demand for modern conveniences and improved sanitation.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Permanganate Consumption, Chlorine Number and Chloramin Number in Water and Sewage Analyses. F. EGGER. Vom Wasser. Yearbook for sanitary chemists and engineers. Printed by: Chemie G.m.d.H. Berlin W. 10, 1928. pp. 56-64. With sodium hypochlorite other values are obtained than with chloramines. The two methods should be kept separate. It is proposed to designate the value obtained with hypochlorite as chlorine number and

that found with chloramin as chloramine number. Chloramines attack urine and albuminoids less than hypochlorite, so that the use of chloramines are of less value since feces-polluted water requires more of the latter. The chlorine numbers are greatly affected by residual chlorine, whereas determinations made by the permanganate method are less affected and consequently of greater value. The two methods cannot be compared directly.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Safer Water and Safer Milk for West Virginia Cities in 1928. E. S. TISDALE. Quarterly Bulletin West Virginia State Dept. of Health, 16: 1, 27, January, 1929. From 1925 the typhoid fever death rate in West Virginia has been dropping steadily from 20.2 to an estimated 9.4 in 1928. This remarkable decrease has been brought about by four factors: (1) safer public water supplies; (2) improved city milk supplies; (3) increasing number of full-time country health units; (4) general education along public health lines. During the year 1928 fourteen cities with a population of 64,500 placed in operation improved or new water supplies. The quality of the supply in six cities was raised from *bad to good* and in eight cities from *doubtful to good*.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Purification of Swimming Pool Water. G. C. DUNHAM. The Military Surgeon, 64: 3, 361, March, 1929. Major Dunham presents the basic facts regarding purification of swimming pool water and operation of pools in a manner especially adapted for use by medical officers. Disinfection is considered the principal dependence, and continuous chlorination in a quantity sufficient to maintain an excess of free chlorine of 0.1 to 0.5 p.p.m. is held necessary for proper treatment. Intermittent chlorination is not recommended. Bathers should take a soap and warm water bath before entering. Periodical draining and cleaning is necessary. Refiltration and recirculation is an aid in operation but does not obviate the necessity for disinfection. There are presented, also, results of a study made by the author on the comparative effectiveness of continuous and intermittent operation, based on the operation of the pool at Carlisle Barracks, Pa.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Preliminary Report on Wading Pools. ARTHUR M. CRANE. Jour. American Association for Promoting Hygiene and Public Baths, 11, 74, 1929. In general little attention seems to have been given to determine the flow of new pure water necessary to maintain wading pools free from colon bacillus; nor have the pools been equipped with filters or disinfecting apparatus. Apparently dependence is being placed on the purity of the supply which in most cases is from the city mains. Inquiries have come from all over the United States regarding the standards for wading pools. After a questionnaire had been sent to a larger number of sanitarians, the conclusions were that wading pools should have the same standards as swimming pools. Data also show that in only a small per cent of cases is water treated and purified.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Report of the Detroit Department of Health on Swimming Pools in 1928. HENRY F. VAUGHAN. Jour. of the American Association for Promoting Hygiene and Public Baths, 11, 45, 1939. In 1928 the city of Detroit had 43 swimming pools available to city swimmers. The average monthly registration was approximately 185,000 which is a large increase over former years. The Department of Health was very well pleased with the 1928 report as it showed that all pools had complied with the Department of Health standards for purity of swimming pool water and maintained these standards through year. Comparative standings are given showing the average monthly attendance, average median bacterial count, actual average per 100 cc. per cent of samples showing colon, per cent showing colon over excess 10 per 100 cc.—A. W. Blohm. (Courtesy U. S. P. H. Eng. Absts.)

Swimming Pool Construction. WM. D. CHAMPLIN. Jour. American Association for Promoting of Hygiene and Public Baths, 11, 21, 1929. Thirty-eight free open community swimming pools are operated by the city of Philadelphia. The pools with few exceptions are 90 feet long, 35 feet wide, spoon type with depths of 3-4½ and 8½ feet providing ¾ area for wading. The walls of pool including scum gutter and floor are poured monolithic, using approved water proofing compound. Pools are filled by three inch pipe at shallow end with three outlets one foot above pool bottom while pool is drained from sump pit located in deepest part of pool covered with iron grate. The total attendance in the 38 pools for the 1928 season was 3,575,835.—A. W. Blohm. (Courtesy U. S. P. H. Eng. Absts.)

The Hygiene of Swimming Baths and Ponds. A. L. THOMSON. Surveyor, 74: 1912, 231, September 14, 1928; Canadian Engineer, 55: 23, 721, December 4, 1928. A general discussion of swimming pool sanitation, with emphasis on the need of efficient purification of the pool water. Illustrating the possibilities for infection of pools from untreated waters, the author cites an example of a pool of 100,000 gallons capacity. When freshly filled, the water of this pool gave a bacterial count of 520 per cubic centimeter, and after being used by 380 bathers, gave a count of 342,000 per cubic centimeter. Quoting from the Standards recommended by a committee of the American Public Health Association, he states that these standards have been adopted tentatively by his city in regulating the operation of swimming pools, and suggests that they be followed until corresponding standards, especially suited to conditions in Great Britain, have been worked out.—A. W. Blohm. (Courtesy U. S. P. H. Eng. Absts.)

Public Baths of Manhattan. B. J. CORCORAN. Jour. American Association for Promoting Hygiene and Public Baths, 11, 35, 1929. The Borough of Manhattan excels in the number of baths and the patronage of these baths in New York City. Manhattan maintains six interior pool baths; also nine interior baths containing showers only and eight floating baths on the East and Hudson Rivers. The floating baths are really large bath tubs floating in the salt water of the rivers and supplied with fresh water from the city mains which flows through a mixing apparatus containing hypochlorite of lime and

is distributed to the tub or pool through nozzles arranged at spaced locations around the bottom. The water is constantly overflowing at the surface into the river. The shower baths are very economical and are well patronized. The Borough also maintains twenty comfort stations.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

An Act Providing for the Inspection and Licensing of Swimming Pools and Making an Appropriation Therefor (Rhode Island State Board of Health). Anon. Jour. American Association for Promoting Hygiene and Public Baths, 11, 82, 1929. This act provides for the licensing of swimming pools not owned or operated by the United States government in Rhode Island. The State Board of Health can make necessary regulations for the sanitary maintenance of all swimming pools and is to make at least one annual inspection and take samples at least twice monthly. A \$5.00 license fee is charged for each three months or fraction that the pool is in operation. The Board of Health is empowered to revoke licenses in case the regulations are violated in which case the owner has appeal to the state courts. The regulations promulgated by the Board are in line with those of the Joint Committee on Bathing Places. Plans for all new pools must be approved and adequate disinfection be provided for all pools.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

State Regulations of Public Baths, Swimming Pools, Laundries or Wash Houses and Comfort or Convenience Stations. Jour. American Association for Promoting Hygiene and Public Baths, 11, 78, 1929. A summary of the regulations in effect in the states and provinces of the United States and Canada show that over twenty states have no regulations. Some have advisory regulations. The majority of the states have regulations based either on the California Swimming Pool act or the regulations of the Joint Committee on Bathing Places. Only a few of the States have regulations governing comfort stations.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Pontefract and some of Its Recent Municipal Works. W. H. NEWTON. Surveyor, 74: 1919, 393, November 2, 1928. The present area of Pontefract, one of the oldest boroughs in England, is 4,078 acres and its population, 18,100. The water works, which supplies a population of 40,000, is obtained from a deep well, with a new source, consisting of a 33 inch bore hole. The per capita daily water consumption is classified as follows: Domestic use, 24.3 gallons; trade use, 5.3 gallons; total, 29.6 gallons. A new 16 inch trunk water main, augmenting an old 12 inch main, has been constructed; likewise a new concrete water tower.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Turbidity and Colour Meter for the Examination of Water by Olszewski-Rosenmuller's Method. (W. Olszewski. Chem. Ztg. 1926, 50: 694.) Wasser u. Abwasser., 1927, 24, 14. Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. "The estimation of colour is carried out by comparing layers 20 cm. in thickness of the water under examination with standard American colour glasses, which are graded according to the colour scale of a platinum-

cobalt comparative solution. Turbidity is determined by means of a half shadow photometer against Ostwald's normal white. Distilled water is used as a comparative liquid."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

A Simple Colorimetric Method for the Determination of pH. (Rossee and v. Morgenstern, *Chem. Ztg.*, 1927, 51, 302.) *Wasser u. Abwasser*, 1927, 24, 12. Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. "The advantage of the method described is that by its use the pH of strongly coloured liquids may be approximately determined. A large drop of the liquid under investigation is introduced into a depression in a porcelain dish and there mixed with the indicator. The colour produced is compared with a scale provided with the apparatus."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Algae in Filter Plants and Their Influence on the Oxygen Balance. (P. Keim. *Tech. Gemeindeblatt* 1928, 300, 332, 346). Department of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. "As a result of his investigations of the algae of the Hamburg water works, Strohmeyer concluded that algae were beneficial in improving the operation of filters, and that those containing chlorophyll effected, by assimilation a marked reduction in bacteria. Later experience has shown, however, that algal growths on filters, unless strictly limited produce many undesirable effects. Although algae tend to accelerate the formation of a filter film, the improvement in filtration effected by the assimilation of bacteria is open to doubt. The conditions for the development of algae, heat, light, air, the presence of nutrient salts, etc., are too difficult to control to ensure regular and satisfactory filter operation. The presence of algae results in excessive fluctuations in the oxygen content of water. The oxygen saturation is usually high during the day time and low at night." Chlorination of the raw or settled Elbe water at Hamburg was found to be a simple means of restraining algal growths. Aluminum sulphate is also effective provided the water is thoroughly mixed. Filamentous algae and diatoms are most susceptible to chlorine and unicellular green algae less. Should the presence of algae in the filter film be advisable, for the treatment of very clear water, this can be brought about by a reduction in the chlorine dose. It is concluded that, in general, the operation of a filter proceeds most satisfactorily when the possibility of biological disturbances such as may be caused by algae is excluded."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Domestic Water Softening Plants. (*Engineering* 1928, 125, 483.) Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, No. 9, July, 1928. "Plants requiring skilled attention and involving accurate chemical dosage are unsuitable for domestic use and therefore the base exchange process is most generally used in domestic installations in this country. Such installations usually consist of a reaction tank, which can be fixed in the rising main of the domestic supply, the flow of water being controlled by stop cocks. The upper part of the tank is usually used for mixing the salt solution for regeneration, which is conveniently

carried out daily. The models which are being manufactured by United Water Softeners, Ltd., William Boby & Co. Ltd., Water Purifiers Ltd., and Electrolux Ltd. are briefly described."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Note on the Colorimetric Titration of Phosphates in Drinking Water by Deniges' Method. (R. Danet, *J. Pharm. Chim.*, 1927, 5, 490); *Chim. et Ind.*, 1928, 20, 462; Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature. Vol. 2, No. 1, November, 1928. "This method, which permits of the determination of 0.1 to 5 mgm. of P_2O_5 per litre, depends on the use of a sulpho-molybdate reagent and stannous chloride. The blue colour produced is compared with standards. Standards prepared from solutions of known phosphate concentration are unstable and Deniges suggests the use of solutions of indigo carmine. The author has shown however that it is impossible to prepare a standard, which will give sufficiently accurate results, with any other substance than phosphate. Further the temperatures of the standards and solution under examination should be the same."—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Report of Regina Water Supply. Anon. *Canadian Engineer*, 56: 8, 240, February 19, 1929. Data given from a report submitted to the city council of Regina by C. F. Layne, Chief Geologist of the Layne-Bowler Co., in which the company offer to construct wells of the gravel wall type at a cost of \$35,000 per m.g.d., if a contract to develop at least 3 m.g.d. is entered into. The existing wells, of which there are more than 125, are believed to have become clogged with fine silt.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

Department of Water Supply, City of Detroit. A Descriptive Survey. October 1, 1928. A series of twenty-nine papers, prepared by the men in charge of the various bureaus of the Department of Water Supply of the City of Detroit, have been assembled, which give the history of the water system since 1824, show its growth and indicate the various administrative, legal, engineering and clerical activities necessary in supplying filtered and chlorinated water to the extent of 200 million gallons daily, through 3,400 miles of distribution piping to a population of 1,760,000 persons.—A. W. Blohm. (*Courtesy U. S. P. H. Eng. Absts.*)

The Fauna of the Bed of the River Moldau in the Neighborhood of Prague, II. Protozoa, Hydrozoa, Crustacea, Tardigrada, Hydracarina, with an Appendix: Ecological Observations and Experiments. H. Kalmus, *Intern. Rev. ges. Hydro-biol. u. Hydrograph.* 1928, 19, 349. (See also Vol. 1, A.160.) Dept. of Scientific and Industrial Research, Water Pollution Research Board, Summary of Current Literature, 2: 1, A-4, November, 1928. "This paper contains complete and detailed lists and descriptions of organisms, belonging to the above groups, found at the 6 stations on the river in the neighbourhood of Prague. In the appendix an account is given of the influence of various physical, chemical and biological factors on the distribution of organisms in the river. III. The Free Living Nematoda. (A. Liebermann. *Intern. Rev. ges.*

Hydrobiol. u. Hydrograph, 1928, 20, 103.) A description similar to the above is given of the organisms of this type in the River Moldau."—A. W. Blohm. (Courtesy U. S. P. H. Eng. Absts.)

Chlorination for Small Towns in Cochin China. J. GUILLERM and M. MECHIN. Arch. Inst. Pasteur d' Indochine, 1926, April to October, 65-74. From Bull. Hyg., 4: 4, 316, April, 1929. This article describes the method adopted at Baria, near Saigon, Indo-China (Fr.), for introducing chloride of lime into a filtered water for disinfection purposes. In comparison with present day practice of introducing liquid chlorine mechanically, the scheme devised is crude, but for the purpose of making the chlorine control method simple and positive, so as to be suitable for coolie attendants, the means described are complete and unique. The usual mixing and storage tanks are in use. Delivery is made to the water through a bent glass tube and the rate is varied by raising and lowering this tube. A weir over which the water passes is visible to the attendant and if the water is up to a certain color mark on the weir, the attendant hangs the tube on a nail of the same color, said nail being in the proper position to deliver the quantity needed for that flow of water.—Arthur P. Miller.

Chlorination of Surface Water at Low Temperatures. G. NACHTIGALL. Arch. f. Hyg., 1928, 100: 25-30. From Bull. Hyg., 4: 4, 317, April, 1929. During the winter of 1927-28 it was found difficult to chlorinate the water of the Elbe at Hamburg (Germany) so as to have an efficient effect and not impart a taste to it. As a result the quality of the water supply was not as good as usual. This is attributed to the fact that the chlorine absorption of the water diminishes with falling temperature. For example, at 1 degree C, it is about 0.1 p.p.m., while at 24 degrees, it is 0.45 p.p.m.—Arthur P. Miller.

Estimation of Iron in Presence of Organic Matter. G. NACHTIGALL and M. BAYER. Arch. f. Hyg., 1928, 100: 35-9. From Bull. Hyg., 4: 4, 320-21, April, 1929. The colorimetric method, using thiocyanate, for estimating iron in water is the most satisfactory and the conditions for accuracy, such as colorless water and iron all in the ferric state, are easily satisfied in the ordinary drinking water supply. However, in a water carrying considerable organic matter, the determination is not so easy. The destruction of this organic matter is usually accomplished by evaporating the water with an oxidizing agent; those commonly used being potassium chlorate and hydrochloric acid, persulphate, and bromide-bromate. The latter is used with acid to take up residue after igniting total solids with alkali carbonate. The writers have improved upon the bromate method by using hydrogen peroxide as the oxidizer which has been found to give greater accuracy with water bearing organic matter.—Arthur P. Miller.

Volumetric Estimation of Sulphate in Water by the Barium Chromate Method. G. NACHTIGALL and F. RAEDER. Arch. f. Hyg., 1928, 100: 31-4. From Bull. Hyg., 4: 4, 321, April, 1929. "To 100 cc. of the water under examination, previously made feebly acid with hydrochloric acid, is added a measured

volume of standard solution of barium chromate in 0.1 *N* hydrochloric acid. The sulphate in the water removes its equivalent of the added barium as barium sulphate; on adding slight excess of ammonia the rest of the barium comes down as barium chromate while chromate equivalent to the sulphate present in the water remains in solution. The solution is then filtered and soluble chromate estimated iodometrically with *N*/100 thiosulphate in the filtrate. This very elegant method is inapplicable in presence of organic matter which will reduce chromic acid; the authors surmount the difficulty by pretreatment of the water with hydrogen peroxide to oxidize interfering organic matter." It is claimed that after applying a correction for the solubility of barium chromate in water, the results are accurate enough to permit the use of this method as an alternate to the gravimetric method.—*Arthur P. Miller.*

Town Water Supply Problems in India. J. W. MADELEY. Surveyor, 1928, 74: 432. From Bull. Hyg., 4: 4, 321-22, April, 1929. Because of the expense and the lack of natural resources, the towns of India are not supplied with water up to their demand. The people in the towns are at first prejudiced against water coming through pipes, but after they become accustomed to it, there is necessity for curtailing waste. In Madras, the mud hut districts are supplied from fountains placed about 200 yards apart. The scarcity of these taps and the necessity of carrying the water, act as a means of reducing waste. For brick houses, two classes of service are given, the charge for both being a tax on the value of the property. The first class is a metered one and the second provides a $\frac{1}{2}$ -inch tap on a $\frac{1}{2}$ -inch pipe, the tap being so placed that it is visible from the road. Prevention of waste calls for unceasing vigilance. *Arthur P. Miller.*

Drinking Water for Travellers in the Tropics. G. C. SHATTUCK. J. Trop. Med. and Hyg., 1928, 31: 220-32, From Bull. Hyg. 4: 4, 322, April, 1929. An African expedition in Liberia and the Belgian Congo gained considerable experience in disinfecting its drinking water. Calcium hypochlorite proved unsuccessful because of deterioration, but Halazone proved stable enough for practical purposes. Enough was used to give taste to the water. For removing mud, potash or ammonia alum are suggested as precipitants. No one on this expedition suffered from dysentery or severe diarrhoea although they were in the tropics for a year.—*Arthur P. Miller.*

Watershed Sanitation and Control. T. P. FRANCIS. Surveyor, 1928, 74: 343-4. From Bull. Hyg., 4: 4, 322-23, April, 1929. Water supplies derived from the ground surface and used without purification are now more liable to contamination since the extended use of motor cars has eliminated the possibility of secluded gathering grounds. In years past the principal guarantee of the safety of water coming from watersheds was inaccessibility, but that has now disappeared to a considerable degree. Afforestation of watersheds checks erosive action of rainfall. Conifers are the most satisfactory trees, as they thrive on poor soil at high altitudes. The return from reforestation cannot be expected to be substantial until at least 50 years after planting.—*Arthur P. Miller.*

Rural Water Supplies. F. W. MACAULAY. J. Roy. San. Inst., 1928, 49: 137-42. From Bull. Hyg., 4: 4, 323, April, 1929. The author states that there is sufficient water in England and Wales to supply a population much greater than the present one and that the difficulty in obtaining water on the part of small communities is the cost of collecting and distributing systems. If small communities were granted the right to take water from a pipe line laid in their vicinity by a larger city as part of the larger city's collecting system, the problem of the small community would at least in part be solved. The British Ministry of Health has advocated the formation of Regional Water Committees to collect relevant data as to potential supplies and future demands.—*Arthur P. Miller.*

Regional Water Committees. Ministry of Health. 8 pp. 1928. London. H. M. S. O. From Bull. Hyg., 4: 4, 323, April, 1929. Insufficient information as to the water resources in England makes impossible a national allocation, but it is practicable at least to divide the country into regions in each of which available supplies and future needs can be studied locally. The needs for at least twenty years ahead should be forecast in detail and those for at least 50 years, on a broader basis. Community of interest in water supply should be the guide in the determination of regional boundaries, and for each region the committee should carry out suggested investigations and studies. Pending the completion of the comprehensive scheme for a region, the regional committee can be of service in advising on local questions as they arise.—*Arthur P. Miller.*

The Water Supply of a Division under Active Service Conditions in Egypt. G. K. FULTON. J. Roy. Army M. Corps, 1928. 51: 186-9. From Bull. Hyg., 4: 4, 323-4, April, 1929. Water for the use of British troops during manoeuvres in 1927 was taken from the El Hagir canal which is grossly polluted. There was danger also of infection with schistosomiasis. Intakes at the center of the canal were provided with rose strainers to exclude snails, and settled water was stored for 48 hours or more. Alum was then added at the rate of six grains per gallon, eight hours allowed for settlement, and the water then run to canvas storage tanks sunk in the ground. Filtration through three stationary regimental water carts was followed by chlorination. No cases of water-borne disease occurred.—*Arthur P. Miller.*

Movement of Water in Alluvium. F. DIENERT. Ann. d'Hyg. Pub. Indust. et Sociaux, 1928, 6: 669-91. From Bull. Hyg., 4: 4, 324, April, 1929. To determine the possibility of procuring a certain amount of underground water in the Loire Valley (France), the studies described here were made. The underground water in this valley comes partly from the bed of a river and a canal by percolation, and partly from drainage from the hills. The point of contact between the hill and the river waters has a to-and-fro movement. As a means of determining the proportion between the two types of water, chemical analysis was used, as the hill water has the larger chalk content. Temperature was also helpful, as the conduction of heat to deep levels in the earth is known to be small. To find the direction of flow in the ground, iron

tubes having perforations were sunk at the angles of a pentagon. In the centre were sunk other similar tubes, into which colored solutions were poured. The strength of the solution as it appeared in the outer tubes gave information concerning the flow.—*Arthur P. Miller.*

Capture of Mineral Water Springs. GRANDJEAN. *Ann. d'Hyg. Pub. Indust. et Sociaux*, 1928, 6: 641-60. From *Bull. Hyg.*, 4: 4, 324-6, April, 1929. This article describes and gives two figures covering methods of obtaining water from mineral springs. Quite a number of unique schemes are described, such as one applying hydrostatic methods to capture water from sulphur springs emerging beneath the water of a lake. A diving bell with its mouth sunk in the bottom of the lake was placed over the spring and the hydrostatic pressure caused the spring water to rise in the bell from which it was drawn off at regulated speed through a siphon tube. One reason for handling mineral spring water by unique methods is that certain waters contain peculiar constituents which it is particularly desired to retain in them.—*Arthur P. Miller.*

Sterilization of Water Bottles by Means of the Lelean Sack. A. C. H. SEARLE. *J. Roy. Army M. Corps*, 1928, 51: 287-92. From *Bull. Hyg.*, 4: 4, 326, April, 1929. The Lelean sack disinfector has been used successfully to sterilize milk bottles. The writer describes experiments made to determine if this disinfector might also be used for sterilizing water bottles in the field. His conclusions are that it is possible to do this with as many as 100 bottles per load in the Lelean sack; that it is not necessary to take special measures to keep the bottles apart, as steam will succeed in finding its way to them however tightly they are packed; and that the sack must be closed, preferably with several blankets. Although the outer layers of the top blanket are not sterilized, it has been shown that a temperature of 100°C. is reached just below that surface.—*Arthur P. Miller.*

Sterilization of Sea Water by Ozone. Application to Purification of Shellfish. H. VIOLLE. *Rev. d'Hyg. et de Méd. Preventive*, 1929, 51: 42-6. From *Bull. Hyg.*, 4: 5, 417, May, 1929. The writer shows that the addition of ozone to sea water does not cause decomposition of the halides, which has always been one of the theoretical objections to it as disinfecting agent therefor. Experimentally, ozone will kill pathogens added to sea water and sterilize it. Further studies described have to do with ozone in connection with shellfish.—*Arthur P. Miller.*

Seasonal and Age Distribution of Deaths from Typhoid Fever in New York, Chicago, and Providence, R. I. J. H. MILLS. *J. Preventive Med.*, 1929, 3: 37-41. From *Bull. Hyg.*, 4: 6, 495-6, June, 1929. No significant change in seasonal distribution of typhoid fever after the establishment of effective water purification methods was found as the result of a study of the seasonal distribution of deaths in New York (1886-1924), Chicago (1881-1927), and Providence (1885-1922). "It is suggested . . . that the distribution of water-borne typhoid may be the same as that of typhoid from other sources,

or that the proportion of water-borne to other typhoid may be unchanged." An analysis of the age distribution of typhoid deaths in New York and Chicago indicates a concentration of deaths in the middle age group. The decline in the extremes of life can probably be attributed to the reduction of the risk of home infection.—*Arthur P. Miller.*

The Montreal Filtration Works. FIELD, FREDERICK E., and HARRINGTON, JOHN H. Jour. New England Water Works Association, 42: 4, 359-71, December, 1928. Filtration Plant placed in service in 1918 was designed for 50 m.g.d. (Imp.) nominal capacity, with 16 pre-filters and 16 final filters operated together as one plant. Although plant was designed for double filtration without use of coagulant, provision was made to permit pre-filters and final filters to be operated as separate, or as partially combined plants. In 1928 the maximum daily output was 97.6 m.g. (Imp.) or 94 per cent in excess of designed nominal capacity of plant. Plant has been running continuously and has delivered satisfactory water at all times in spite of excessive overload on filters. Thirty-two new filters now under construction will raise the nominal capacity of the plant to 150 m.g.d. (Imp.). The design permits the washing of only one filter at a time. An elaborate clock and signal system will inform the filter operator in one gallery whether or not filter washing is in progress in either of the other two galleries. Tables giving operating data and costs of operation are included.—*H. H. Gerstein.*

Recent Developments in Water Purification. WELLINGTON DONALSON. Jour. New England Water Works Association, 42: 4, 372-77, December, 1928. The most notable recent advances have been concerned with processes, or modifications of processes, rather than with new types of structures. Of structural changes noted in a survey of the most recent purification plants, the most important are concerned with mechanically-cleaned settling basins, mixing facilities, and aeration. Many plants are making use of split dosage chlorination. Chlorination of both raw and filtered water is practiced where heavy bacterial loads exist. Treatment of water, instead of being simplified, is becoming more complex and highly specialized.—*H. H. Gerstein.*

The New Water Works System of the Greenwich Water Company. DANA M. WOOD. Jour. New England Water Works Association, 42: 4, 378-95, December, 1928. Describes historical development of Greenwich Water Company and its existing plant prior to recent improvements. Outlines study of several possible sources of additional supplies and needs of the Company. Due to lack of water for pressure testing new laid pipe lines, air pressure testing was resorted to. Air test is more severe than water test, since air will show through joint where water will not.—*H. H. Gerstein.*

The New Purification Plant of the Greenwich Water Company. E. SHERMAN CHASE. Jour. New England Water Works Association, 42: 4, 396-409, December, 1928. Detailed description of newly constructed filtration plant of 4 m.g.d. rated capacity. New gravity rapid sand filters may be operated in parallel with old pressure filters. Soda ash is applied to filtered water to prevent increase in corrosive properties.—*H. H. Gerstein.*

The Effect of Sunlight on Determination of Chlorine by the *ortho*-Tolidin Method. McCrumb, F. R., and KENNY, W. R. Jour. New England Water Works Association, 42: 4, 410-13, December, 1928. Experimental data presented show that direct sunlight accelerates color formation in the determination of residual chlorine by *ortho*-tolidin method, and then causes rapid fading of color. In diffused daylight a longer period after addition of reagent is required for maximum color formation. However, rate of fading is very slow. Satisfactory determinations can be made in direct sunlight if the point of maximum color formation is observed. In all cases maximum color should be read instead of that observed after a fixed time interval. Samples of chlorinated water undergo appreciable reduction in residual chlorine concentration when exposed to sunlight in clear glass bottles. Brown glass bottles should be used in transporting samples.—H. H. Gerstein.

The Rainfall of New England. Part IV. The Minimum and Maximum Monthly Rainfall of Southern New England. J. HENRY WEBER. Jour. New England Water Works Association, 42: 4, 414-30, December, 1928. The last of a series of four papers on rainfall in New England. Very complete and detailed data from 1881 to 1925.—H. H. Gerstein.

The Rainfall of Northern New England. GRAGG, RICHARDS. Jour. New England Water Works Association, 42: 4, 431-56, December, 1928. Detailed study of rainfall of Northern New England with data from 1881-1925.—H. H. Gerstein.

Proper Feed Water Control. Chem. & Met. Eng., 36: 8, 467, August, 1929. Abstract of paper by S. T. POWELL on "Operation and Control of Boiler Feed Water Purification Systems." Heavy losses have been sustained in some of the large industries from bad feed water control. A chart is given showing the comparative cost of tube renewals before and after introduction of control for 5 stations.—John R. Baylis.

Effect of Sieve Motion on Screening Efficiency. Chem. and Met. Eng., 36: 8, 479, August, 1929. Extracted from U. S. Bureau of Mines, Serial No. 2933, by A. W. FAHRENWALD and S. W. STOCKDALE. Different sieve motions were tried. The types of sieve motion tested in the order of their decreasing relative efficiencies were:—vibrator motion, side-tap motion, bottom-tap motion, and ro-tap motion.—John R. Baylis.

Silt Transportation by Sacramento and Colorado Rivers and by the Imperial Canal. C. E. GRUNSKY. Proc. Am. Soc. Civ. Eng., 55: 6, 1473-1502, August, 1929. Surveys to determine the frequent changes in the elevation of the bed of the Imperial Canal have furnished an opportunity for estimating the volume of silt transported by the canal. Over a period of 2½ years deposits followed by erosion have averaged in excess of 500,000 cubic yards per month, with a canal flow of about 2,000,000 acre-feet per year. The suspended load of silt in the Colorado River has been determined at Yuma, Arizona. Silt in suspension in the Imperial Canal at its head, in 1914, averaged 0.86 per cent of the weight

of the water, and in the Colorado River it averaged 0.93 per cent. Numerous observations give the varying quantities of silt at different stages of the Colorado River and the total volume transported during the period of observation since 1909.—*John R. Baylis.*

Niagara Power. NORMAN R. GIBSON. *Proc. Am. Soc. Civ. Eng.*, 55: 7, 1719-46, September, 1929. This paper presents a general picture of the engineering phases of the power plants at Niagara Falls, illustrating their principal characteristics and tracing their development. It discusses some of the newer problems and directs attention to the significance of Niagara power in the industrial development of the surrounding territory.—*John R. Baylis.*

Regulation of Levels, Flow, and Navigation, Niagara River: Summary and Conclusions of Various Studies. GEORGE B. PILLSBURY. *Proc. Am. Soc. Civ. Eng.*, 55: 7, 1747-58, September, 1929. Discusses the factors relating to the regulation of the Niagara River. The problem is to find in what manner the flow can be altered to produce benefits that outweigh the cost and resulting injuries. The author concludes that the results of the studies made by various agencies have not indicated the advisability of regulating the flow of the Niagara River.—*John R. Baylis.*

Filtering Materials for Water and Sewage Works. Progress Report of the Committee of the Sanitary Engineering Division. *Proc. Am. Soc. Civ. Eng.*, 55: 7, 1799-1844, September, 1929. The efforts of the committee during 1928 were directed towards the development of laboratory methods to assist in the selection of filter material for sewage trickling filters.—*John R. Baylis.*

Iron Removal Plants for Small Water Supplies (Kleinenteisener für Einzelwasserversorgungen. Erwiderungen auf den Aufsatz, Mangel an Enteisenerungsanlagen für Einzelbrunnen). ERICH BIESKE and FRANZ SCHUBERT. *Gas- und Wasserfach*, 18, 423, May 4, 1929. This paper is in reply to a lecture by Dr. R. SCHMIDT, of the Prussian Institute for Water, Soil, and Air Hygiene at Berlin-Dahlem, published in *Gas- und Wasserfach*, 6, 127, 1929. The author described in detail various removal processes, applicable to removal of iron in (1) wells, (2) homes, (3) small distribution systems. For the removal of iron at the well installations generally known as "Iron Removal Pumps" are used. Such installations are desirable in the country where water free from iron is desired. Such smaller establishments as County Schools, etc., are best served by local installations, operated either by hand or by pressure.

In larger institutions, such as hospitals, asylums, etc., which are usually supplied from an overhead tank and distribution system, it is desirable to insert the iron-removal apparatus into the distribution system, so that the process may take place automatically.—*Richard F. Wagner.*

Corrosion Experiments with Iron (Korrosionsversuche mit Eisen). WILHELM VAN WULLEN SCHOLTEN. *Gas- und Wasserfach*, 19, 456, May 11, 1929. The author recites, briefly, the most recent experiments which have been undertaken by research agencies scattered over the globe. He elaborates,

particularly, on the degree of corrosion as a result of sand blasts, bending, punching, and high temperatures and points out that the microscopic examination of the surface of test pieces has proved helpful. He states that many observations have been made which have been useful in practice, such as the prevention of corrosion by the introduction of an electric current, which will be the subject of a future paper.—*Richard F. Wagner.*

Filter of Activated Carbon to Improve the Tests of Chlorinated Water (Filter aus aktiver Kohle zur Verbesserung des Geschmacks von gechlortem Trinkwasser). IMHOFF and SIERP. Gas- und Wasserfach, 20, 465, May 18, 1929. Though chlorine is in general use for the sterilization of water supplies, its application has one disadvantage, namely, of leaving, at times, disagreeable after tastes. This is particularly true, when the raw water contains traces of phenols. While attempts have been made to remove such phenol from industrial wastes, they have not been successful. In consequence, quite a deal of research has been undertaken to eliminate chlorine-phenol tastes from drinking water proper. Filters of activated carbon have previously been used to sterilize water. The authors have checked the experiments of ADLER, who has used such a filter to remove excess chlorine. It was found that filtered water only should be used in the carbon filter, which consisted essentially of a glass container filled with activated carbon of grain size averaging 2 mm. Water containing 1 p.p.m. of chlorine and the same proportion of phenol showed no tastes until the filter agent had absorbed from $1\frac{1}{2}$ to 2 per cent of its weight of phenol. Since then, one of the larger water supplies of the Ruhr Association has placed in operation a taste removal plant based on the experimental unit. The results, so far, have been very successful.—*Richard F. Wagner.*

Flushometers with Water Seal Breakers for Toilet Supply Lines (Spülhahnen mit Rohrunterbrecher für Abortspüleleitungen). E. LINK. Gas- und Wasserfach, 21, 489, May 25th, 1929. The author, who is in charge of works which are supplied with 92,000 flushometers, states that such fixtures have effected a saving of 40 per cent in the amount of water formerly required by tank closets. Various flushometers are fully described and the importance of a proper water seal breaker is stressed. An installation for testing the equipment for possible siphon action, with consequent danger of polluting the public supply, is shown. The paper closes with the regulations of the Stuttgart Water Works governing the installation of flushometers.—*Richard F. Wagner.*

NEW BOOKS

Proceedings, Organization Conference of Virginia Water and Sewage Works Association, Richmond, April 25 and 26, 1929. Mimeographed. Outline of organization meeting given, together with text of constitution which was adopted. **Treatment of Staunton's New Gravity Water Supply to Reduce Corrosion.** W. F. DAY. For many years Staunton obtained its domestic water supply from limestone springs located within city limits, water from which was very hard. In August, 1926, a new supply from North River was placed in commission at cost of over \$800,000. System consists of 125-m.g.

storage dam and works about 15 miles from city in National Forest, water being conveyed to city through 16-inch cast iron main and distribution reservoir of 3.75 m.g. capacity with aerators. About one year later complaints of red water were received and lime treatment (50 pounds per m.g.) was adopted, increasing pH from 6.6-7.2 to 7.8-8.4. Hot water systems still give trouble and difficulties have been experienced with stoppage of services by tuberculation. As result of investigation a treatment plant is being constructed at North River works to protect supply main to city. Plant will consist of chemical feed equipment and sedimentation basins. It has been found that the service pipes can be cleared by allowing a 10 per cent solution of sulfuric acid to remain in line 4-5 hours, blowing out with compressed air and flushing thoroughly. Application of dry steam is also effective, the pipe expanding faster than incrustation, resulting in loosening of latter, which then can be flushed out. In Discussion, W. W. WATKINS stated that treatment of Norfolk water with lime, increasing pH to 8.4-9.0, has considerably reduced corrosion. Observations have indicated that corrosion increases with content of dissolved oxygen. A. WAGNER stated that sodium hydroxide had been substituted for soda ash at Danville as it was cheaper, only one-third the amount being required. J. W. ENGLE reported that soda ash and sodium hydroxide had been employed at Big Bethel and lime finally adopted. The Charlottesville Filtration Plant (Slow Sand Filters). L. H. WILLIAMSON. Prior to 1923 Charlottesville's water supply was derived from 2 impounding reservoirs, located 3 miles from city, water of which becomes highly discolored and has disagreeable taste and odor during summer months. To relieve the inadequacy of this supply, a station was constructed to pump water from Maury Creek into reservoir. After investigation, a 2-m.g. slow sand filter plant was constructed and put in operation in November, 1922, and a new supply was developed from Moorman's River and put in use on March 30, 1925. Filter plant consisted of 4 units containing 36 inches of sand having an effective size of 0.36 mm. and uniformity coefficient of 2.0, operated at rate of 5 m.g.d. per acre, aerators, and clear well. During first summer of operation reservoir water was at its worst due to drought and stagnation. The beds clogged rapidly and had to be cleaned weekly. The aerators caused a precipitate to form in clear well having appearance of red mud, in which small red worms bred. This condition was found to be due to high iron content and was corrected by aeration prior to filtration. Unexpectedly, clogging was also relieved, minimum period between scrapings being increased to 2 weeks. To meet increasing demands plant was altered in June, 1926, to be operated at 10 m.g.d. per acre. Aerator and drainage system capacities were increased and provision made for 15 minutes sedimentation prior to filtration for partial settlement of the natural iron floc. Cost of alterations was \$8,468.42 per m.g. of increased capacity as compared with estimated cost of \$51,000 for new filters of this capacity to be operated at 5 m.g.d. per acre. Average time between scrapings at 10-m.g. rate approximates 50 days, or only 10 per cent less than at 5-m.g. rate. Sanitary and physical characteristics of effluent have not been impaired by increased rate. Construction of coke screen over outlet of preliminary aerators relieved filters of considerable load. Costs of operation at the 5- and 10-m.g. rates over corresponding periods were \$7.38 and \$6.65 respectively.

Cost of operation during past year was \$5.99 per m.g. Fixed charges over entire period of operation average \$13.53 per m.g., including sinking fund for retirement of outstanding bonds, making total cost at present \$20.18 per m.g. Raw water color and turbidity range between 20 and 27 p.p.m., and iron content is approximately 0.75 p.p.m. In Discussion, L. L. HEDGEPEETH stated that reservoir in Elizabeth City on occasions becomes infested with red and white worms. It was discovered that they were larvae of the midge fly. Superchlorination up to 1.2 p.p.m. killed the larvae but not the eggs. W. DONALDSON reported that Urbana, Ill., had had similar experience with red worms. **The Richmond Water Supply.** G. H. WHITEFIELD. Early history of supply, derived from James River, is described. **Length of Filter Runs.** R. J. LEVEQUE. Substitution of soda ash for lime and changing point of chemical application to give proper distribution of coagulant between the 2 basins has increased length of filter runs at Fredericksburg. Coagulants are now applied in suction pipe of pumps, mixing being effected by pumps and in mixing chambers of around the end type. Jar tests are found most useful for determining best coagulant dosage. Optimum pH appears to be 6.6-7.0. Algae cause stringy floc and reduce filter runs. Copper sulfate eliminated this condition in 2 days. Repacking of valve stems reduced air binding to some extent. Closing effluent valve for few minutes and then using re-wash valve often postpones washing for several hours when air binding is troublesome. Use of re-wash valve for 3-10 minutes after washing filter will not only lengthen runs but also improve quality of effluent. Filters washed just prior to shutting plant down for night run for 2-5 hours longer than those washed at any other time. Natural settling occurring overnight seems to form unbroken mat over sand bed which is even better than that formed by slow re-wash. Data included on cleaning of sedimentation basins. **Chlorinated Copperas and Ferric Chloride as Coagulants.** L. H. ENSLOW. It has been found at a number of places that color removal by coagulation with alum could be materially improved if raw water were first chlorinated. Author believes that presence of ferrous compounds in raw water constitutes at least one valid explanation of this effect of prechlorination, the iron becoming immediately effective as a coagulant when oxidized by the chlorine. Lime has always been used with ferrous compounds employed as coagulants in order to effect oxidation, and owing to the high alkalinity necessary (pH 9 or higher) this method has not usually been found satisfactory for soft colored waters. Ferric chloride is an excellent coagulant and is satisfactory at low (5.0), as well as at higher pH values, but has been used only to limited extent apparently due to cost. Chlorinated copperas was first used in sewage treatment as cheap source of ferric iron, and has been in use for about a year at Elizabeth City, N. C., for coagulating highly colored water. Apparatus employed is very simple, consisting of dry feed machine which delivers copperas to small baffled solution vat and a chlorinator. The chlorine is introduced into the pipe line conveying copperas solution to point of application to water. Theoretical ratio of chlorine to copperas ($\text{FeSO}_4 \cdot 7 \text{H}_2\text{O}$) is 1:8, but it is advisable to add about 10 per cent of chlorine in excess. Optimum pH for very highly colored swamp waters is within zone 3.8-4.7. Experiments with tannin have shown that maximum dispersion occurs at pH 8.2-9.2. This explains in part the failure of ferrous

salts and lime in organic color removal and inefficiency of alum salts at pH values above 5.5. For coagulation of soft turbid waters carrying no appreciable soluble color, ferric coagulation is usually efficient at almost any pH value up to and including point at which corrosive quality has been corrected by alkali addition. Ferric floc is higher in gravity than alum floc and is very bulky when first formed, but after settlement it shrinks markedly. It has been found that color removal can be effected with less ferric salt than alum and cost data given appear favorable. **Discussion.** E. S. HOPKINS. Laboratory experiments at Baltimore on Gunpowder River water showed that chlorinated copperas was a very satisfactory coagulant, quite comparable with alum. Coagulation was obtained at relatively low pH values, 6.4-6.6, raw water having pH value of 7.1. Relative amounts (grains per gallon) of different coagulants required to produce settleable floc in water having turbidity of 25 (finely divided) were as follows: chlorinated copperas 1.03; ferric chloride ($6\text{ H}_2\text{O}$) 0.7; ferric sulfate 1.0; mixture of equal parts of ferric chloride and ferric sulfate 1.03; alum 0.7. **The Use of Chlorinated Copperas at Chickasaw, Mobile County, Alabama.** A. C. DECKER and H. G. MENKE. Water supply of Chickasaw, derived from Eight Mile Creek, is treated in plant consisting of sedimentation basin, mixing chamber, coagulation basin, two 0.5-m.g.d. rapid sand filters, and chlorinator. Raw water has color of 40-130 p.p.m., turbidity of 3-25 p.p.m. and pH value of 5.5-5.9. Filter plant was completed in April of this year and series of experiments was carried out to determine which was the most suitable coagulant. Chlorinated copperas was tried alone and in conjunction with sodium aluminate. Good coagulation was obtained with 0.7 grain per gallon of ferrous sulfate and 0.126 grain per gallon of chlorine, latter giving excess of 2 p.p.m. at end of mixing basin, which, however, was completely used up in coagulation basin. Sodium aluminate, when used, was introduced at rate of 0.4 grain per gallon. In all cases sufficient lime was added either before or after filtration to adjust pH to 7.0-7.2. Addition of lime after filtration was found more satisfactory. Color was increased when lime was added to clear well but final color was less than when lime was introduced into coagulation basin. Final color was probably not more than 3. With chlorinated copperas alone, floc was apparently lighter and was carried in comparatively large quantities a greater distance through coagulation basin than floc obtained when sodium aluminate was also used, it being noted, however, that under latter conditions the floc which remained suspended after first heavy deposition was lighter than with chlorinated copperas alone. Final effluent was practically the same in each case. Additional cost of sodium aluminate therefore seems unwarranted, cost being greater than that of copperas, chlorine, and lime combined. **Prechlorination and Filtration of the Newport News Water Supply.** E. F. DUGGER. Water supply of Newport News is drawn from impounding reservoirs, the one directly connected with filtration plant having storage capacity of 844 m.g., equivalent to 200 days' supply. Drainage areas are to a great extent uninhabited. Springs and streams entering reservoirs are kept clear of sediment and water is therefore usually very clear. Water entering plant has average color of 30, alkalinity of 85, and turbidity of 10 p.p.m., bacterial count averaging 250 per cc. Coagulants are introduced into suction of centrifugal pumps, thorough mixing being effected

in this way. Chlorine is applied first at rate of 0.3-0.4 p.p.m., and then alum at rate of 9-10 p.p.m. Amount of settlement in coagulation basin conclusively shows value of prechlorination. Before adoption of this method, it was not necessary to clean basin more than once in 5-6 months, whereas now, basin must be cleaned at least once in 30 days. Floc obtained is much finer and more dense, and amount of alum required is less. Length of runs is increased and percentage of wash water decreased; cracking and hard spots in sand bed have practically disappeared. Cost of operation in 1922, prior to prechlorination, was \$12.53 per m.g.; that in 1928, \$7.65. Part of this reduction, however, was due to substitution of 17 per cent alum for 22 per cent alum, former giving floc far superior to latter. Prechlorination has also aided in keeping plant free of algae growths. Sufficient chlorine is applied after filtration to maintain residual of 0.20 p.p.m. There are 8 rapid sand filters of 1 m.g.d. capacity each.

Prechlorination and Filtration of Colored Waters at Norfolk, Va. W. W. WATKINS. There are 2 rapid sand filter plants in Norfolk, the Moores Bridges plant, treating water impounded in series of lakes connected by canals, and Lake Prince plant, treating water from Lake Prince, which is conveyed a distance of 20 miles. Color of former averages 50-60, occasionally reaching 160, and turbidity, 25 at times being as high as 5000; while color of latter averages 70, with maximum of about 200, turbidity never exceeding 50. Chlorine (6-7 pounds per m.g.) is applied just prior to alum at both plants, filter effluents also being chlorinated. In addition to saving in alum, which amounts to 0.4-0.6 grain per gallon, prechlorination increases filter runs, reduces wash water, and maintains filter beds in better condition. Saving in alum, lime (less carbon dioxide to be neutralized), and wash water is about \$5-\$7 per day. At the Lake Prince plant trouble was experienced with taste and odor due to *Asterionella*. Prechlorination has eliminated this difficulty. Lime is added to increase pH value to 8.6-9.0 to prevent red water. This trouble is now confined to dead ends.

Hard Spots, Cracks, and Mud Balls in Filters. R. W. FITZGERALD. Chief causes of hard spots and mud balls are improper coagulation, bacterial and algal growths, and low-velocity washing for insufficient periods. Cracks and fissures are usually caused by improper washing or bacterial growths. There is no one remedy for these troubles. Where bacterial load is high, or algae troublesome, prechlorination has been found effective. High-velocity wash is one of best methods of maintaining filter bed in good condition. Most successful method of removing hard spots is to break up the area with a pole and to give filter long hard washes. If filter can be left out of service and allowed thoroughly to dry out, mud balls will disintegrate and can easily be washed out. Removal by passing longhandled screen through suspended sand during wash has proven fairly satisfactory. Scraping off top layers of sand at regular intervals has also been found useful. Another method employed is that of jetting sand from one filter to another and screening out the mud balls as it enters the second filter.

Care and Adjustment of Controller Gauges and Other Mechanical Equipment. R. F. WAGNER. Brief general discussion of care of mechanical equipment at Lynchburg, Va., plant, particularly the Venturi rate of flow controllers. While the chemical feed controllers were designed to work automatically by an electrical device geared to Venturi meter, this method was found impracticable, and flow from

orifice is therefore calibrated manually once an hour. Method employed for re-packing hydraulic gate-valves is outlined. Packing hardened by use can be revived by hammering after washing in strong solution of soda ash, and coating thoroughly with mixture of extra light petroleum jelly and flake graphite. **Keeping Books on the Filter Plant.** W. DONALDSON. General discussion of filter plant records and their value. Adequate records are a necessity for efficient and economical operation. Record of bacterial quality is the most important. Next in importance to keeping good records is the summarizing of these records. Much valuable detailed information becomes unavailable through lack of suitable summaries systematically prepared.—*R. E. Thompson.*

Protective Metallic Coatings. H. S. RAWDON. Am. Chem. Soc. Monograph Series. New York: Chemical Catalogue Co. Inc. 277 pp. \$5.50. From Chem. Abst 22: 1318, April 20, 1928.—*R. E. Thompson.*

A Treatise on Chemical Engineering Applied to the Flow of Industrial Gases, Steam, Water, and Allied Liquid Chemicals, Including the Pneumatic Transport of Powders and Granulated Materials. With Details for Calculating Fan Power, Pumping Power, Friction Losses in Pipes and the Like, Together with Full Practical Details for Measuring Flow and Viscosity of Gases and Liquids. GEOFFREY MARTIN. London: Crosby Lockwood and Son. Cloth; 7 x 10 in.; 63s. Reviewed in Eng. News-Rec. 101: 742-3, November 15, 1928.—*R. E. Thompson.*

Hydraulic Laboratory Practice. Comprising a Translation, Revised to 1929, of Die Wasserbaulaboratorium Europas. Including Also Descriptions of Other European and American Laboratories and Notes on Theory of Experiments With Models. Edited by JOHN R. FREEMAN. New York: The American Society of Mechanical Engineers. Cloth; 9 x 12 in.; 866 pp. \$10. Reviewed in Eng. News-Rec. 101: 926, December 20, 1928.—*R. E. Thompson.*

Elements of Hydrology. ADOLPH F. MEYER. 2nd. Ed. revised. Cloth; 6 x 9 in.; 522 pp. \$5. Reviewed in Eng. News-Rec. 101: 929, December 20, 1928.—*R. E. Thompson.*

The Control of Floods by Reservoirs. PAUL BAILEY. An Appendix (Bull. 14) to the Summary Report to the California Legislature of 1927 on the Water Resources of California and a Coördinated Plan for Their Development. Sacramento, Cal.; State Dept. of Public Works, Division of Engineering and Irrigation. Paper; 6 x 9 in.; 300 pp. Reviewed in Eng. News-Rec. 101: 597, October 18, 1928.—*R. E. Thompson.*